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# PRELIMINARY STUDIES UTILIZING PAPER ELECTROPHORESIS AS A TOOL IN INSECT SYSTEMATICS[1]

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Department of Entomology, University of Missouri

Entomologists today are seriously handicapped by our relatively poor knowledge of the basic physiology and biochemistry of insects. Determination of both the qualitative and quantitative biochemical complexes of individual insects is an extremely difficult task. This difficulty is due principally to one major factor, i.e., the small size of most insects. Analysis of component parts of insects by routine chemical and spectrographic procedures often requires sample sizes which are far in excess of what might be obtained from a single insect. When the problems of quantitative chemical determination of ultramicro quantities can be solved, biochemical analysis of insects may become routine procedure.

The application of paper chromatographic techniques has, to a great extent, minimized the problem of sample size. Recent research applying chromatographic analysis to insects has been done by Micks and Gibson (1957), Micks (1954), Lewallen (1957) and Buzzati-Traverso (1953), to mention only a few. For large molecules, however, such as the proteins, chromatography is somewhat inadequate. A technique relatively new to the biological sciences has recently been employed in more and more entomological research. This technique, called paper electrophoresis, separates compounds on the basis of their electrical charge, molecular weight, and affinity for a buffering agent. A more detailed explanation of the theory of electrophoresis and its applications may be found in Block, Durrum and Zweig (1954) and Lederer (1955). The variety of compounds separable by electrophoresis is almost unlimited and the quantities which may be analyzed may be as small as one-half lambda (0.0005 ml.) (Stephen and Steinhauer, 1957). Thus the entomologist now has at his command a tool for biochemical investigations in basic physiological research, insecticide research, nutritional studies, taxonomy, etc.

In the summer of 1956, the Missouri Conservation Commission initiated investigations of the principal cause of acorn depredation in the state of Missouri. The following autumn over 38,000 acorns representing fifteen species of oaks were collected from all parts of the state. Some of the insects infesting these acorns were reared, and it was found that over 99 per cent of the invading insects were members of the genus *Curculio* (Coleoptera, Cur-

[1] Research supported by a grant from the Missouri Conservation Commission. Electrophoresis apparatus made available by funds from the University Research Council, University of Missouri.

Contribution from Missouri Agricultural Experiment Station, Journal Series No. 1869. Approved by Director.

culionidae). It was then decided to attempt a morphological separation of the last larval instars of the various species. Until recently separation of larval Scolytidae from Curculionidae using morphological characters was impossible. A separation, then, on the species level within the Curculionidae, posed a problem which seemed almost insurmountable. Over 200 larvae were examined initially but morphological characters appeared to be as variable on the same insect as between different forms. Only three characters seemed to possess consistent specific differences, but even these differences were exceedingly small. It was then decided to attempt a separation on the basis of a physiological character. Concerning physiological characters, Mayr, Linsley and Usinger (1953) have stated: "Physiological characters have been very unevenly exploited for taxonomic purposes. Yet in constancy, diversity, and significance they probably far exceed morphological characters."

Of the vast number of physiological systems present in an insect, the hemolymph probably is most suitable for qualitative and quantitative determination of component parts. This is due chiefly to its liquid state. Since many organic compounds are present in the hemolymph, the problem is to select a class of compounds which are indicative of specific relationships and yield reproducible patterns. The constancy of serum proteins has been established in a number of ways, especially by their usefulness in clinical diagnosis. Boyden (1943) in studies of the sera of crustacea, stated:

"1. The antigenic composition of animals is an important part of their essential natures and must be considered in any sound natural system of classification.
"2. Protein antigens are conservative hereditary traits.
"3. Good precipitin techniques are well adapted to reveal the relative degrees of biochemical similarity of protein antigens."

Nuttal (1901), Landsteiner (1945), and Leone (1947) have also demonstrated the specificity of serum proteins. Since the specificity of these serum proteins has been adequately demonstrated in other animals, both vertebrate and invertebrate, there is no reason to doubt its existence in insects.

Before proceeding further, it should be emphasized that it is not the intention here to use serum proteins as a means of taxonomic discrimination *per se*. At the present time, our knowledge of the composition of serum proteins in insects is far from complete and does not warrant dependency on this character alone. Serum proteins should be used merely as another taxonomic character, to be analyzed together with morphological findings to define taxa. Where protein patterns and morphological characters correlate, a better estimate of the validity of a species may be made.

## METHODS

A horizontal electrophoresis cell was used in these experiments. The buffer compartments of the apparatus were filled with veronal (a sodium barbital-acetate solution) with a pH of 8.6 and an ionic strength of 0.05. Filter paper strips, type S&S 2043A, were stretched between the compartments and wetted by means of an atomizer filled with the buffer solution. The area containing the strips was then sealed under a heavy glass plate and an electrical potential applied. This blank run permitted the apparatus

to arrive at a stable operating temperature and aided the saturation of the area between the glass plate and the paper.

Rubber gloves were used in handling the larvae obtained from the rearing sets, and only mature larvae which had emerged naturally from the acorn hosts were used. Each larva was held manually while the point of a sharp, hooked scalpel blade pierced the ventral thoracic integument. The issuing hemolymph was then drawn into a capillary tube and expelled into

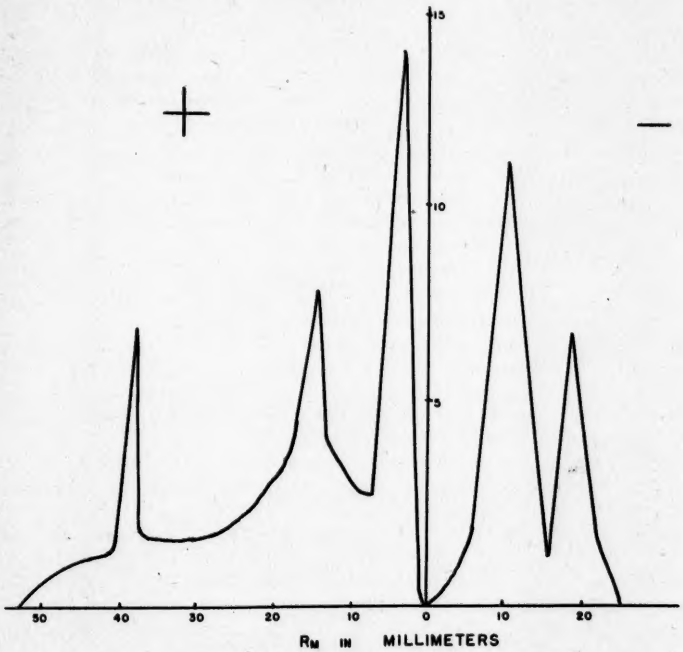


FIG. 1.—Frequency distribution of the hemolymph proteins of 54 *Curculio* larvae exhibiting the relative migration (Rm) in millimeters from the origin (O) to the positive (+) and negative (—) fields. Five protein fractions are present.

the polished bottom of a depression slide. A calibrated ultramicro pipette was filled from the slide to the 1-lambda mark and applied to the center of a paper strip. Six individual larval samples were run simultaneously, each run lasting nine hours at a current of seven milliamperes. The papers were dried in a hot air oven at 130° to 140° C. for 30 minutes and stained in bromphenol blue for six hours. After two rinses in 5 per cent acetic acid and a fixing bath of 5 per cent acetic acid plus 3 per cent sodium acetate (50-50 v/v), each for six minutes, the papers were air dried at room temperature for at least 24 hours. Scanning of the stained strips was accomplished

with a Photovolt transmission densitometer and a graphic record of the number of spots and the densities of each was made.

After the larvae had been tapped, they were preserved in KAA solution for subsequent dissection and mounting. The dissected parts were soaked in 10 per cent potassium hydroxide overnight and after maceration was complete were mounted on microslides in Hoyer's medium. Images of the larvae were then projected through a compound microscope and traced directly to assure all possible accuracy in retaining proportionality of component parts.

## RESULTS

A frequency distribution of the resulting spots on the strips clearly showed five distinct fractions, three migrating anodically (positively) and two cathodically (negatively) (Fig. 1). Analysis of the individual strips for gross differences yielded seven patterns, as follows:

1. 3 positive spots and 2 negative spots
2. 2 positive spots and 2 negative spots
3. 1 positive spot and 2 negative spots
4. 3 positive spots and 1 negative spot
5. 2 positive spots and 1 negative spot
6. 1 positive spot and 1 negative spot
7. 3 positive spots and 0 negative spots

Examples of these distributional patterns may be found in Figure 2. A number of quantitative differences were found on these strips, but for the present only qualitative differences will be considered.

A total of seven species of adult *Curculio* have been identified to date from reared material obtained from the entire state.[2] As more material is secured the number of species may increase.

Three characters were examined for morphological distinction of the *Curculio* larvae: the shape and size of the frontal triangle, the angles and lengths of the epipharyngeal rods, and the number of setae on the dorsal face of the mala. We believe that the size of the present sample is inadequate for statistical appraisal, but it seems evident that individual groups will correlate quite closely with serum patterns and morphology.

## DISCUSSION

The foregoing information indicates protein specificity in species of *Curculio*. The only factor which clouds the entire picture is that of relatively small sample size, but this problem is being overcome at the present time.

The data at hand show that 22 of the 50 samples were of the pattern 2-1, representing 44 per cent of the entire collection. This preponderance of the serum pattern would seem strange except for the fact that of 280 adult curculios examined, 41 per cent were members of the *C. strictus-C. nasicus* complex. It seems probable that with the proportions so close, this pattern represents that complex. One other fact which indicates this specificity is that for seven gross serum patterns identified to date, seven corresponding adult forms have appeared. Data are being accumulated which seem to confirm these specific relationships.

[2] Determinations by Alberto W. Vazquez, George Washington University.

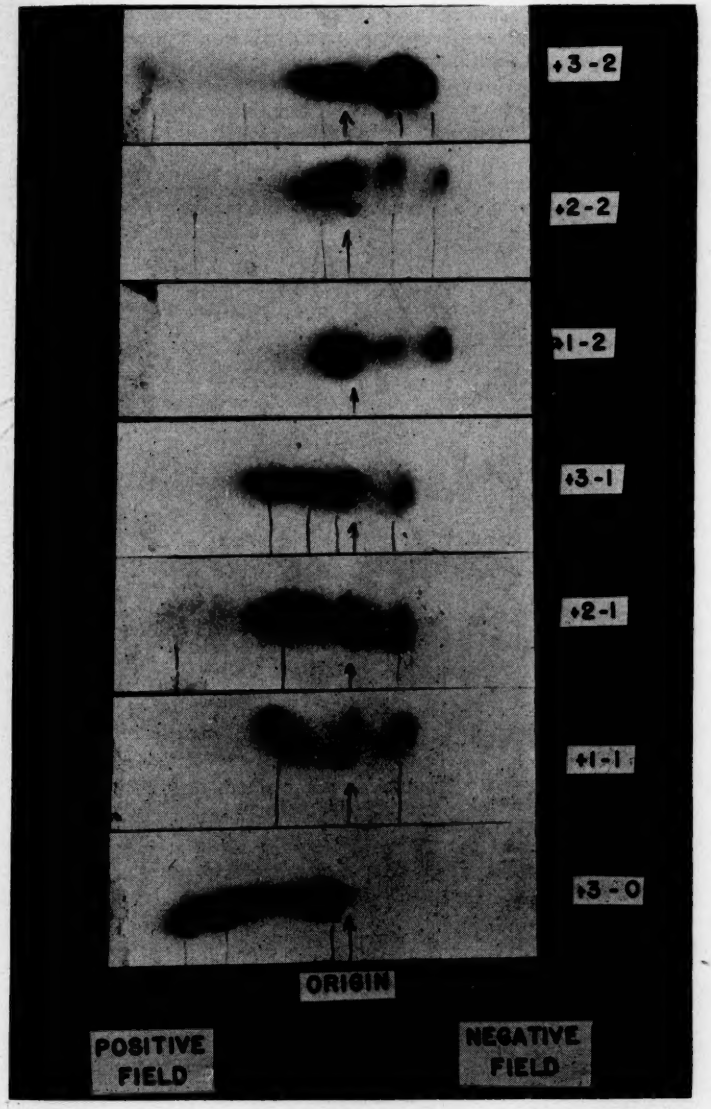


FIG. 2.—Stained electrophoresis strips of the hemolymph proteins of *Curculio* larvae showing seven patterns as indicated at the right. The origins are indicated by the arrows.

The object of this paper has been to demonstrate how a new tool of biochemical analysis may be exploited in solving problems with which the systematist may be faced. Electrophoresis should not be considered as a final answer to taxonomic problems but as a method which is ideally suited for ultramicro analysis and which may be used by the biochemist, physiologist, insecticide research worker, and the systematist.

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# A NEW SPECIES OF *CRYPTOBATES* ESAKI FROM BURMA (Hemiptera: Gerridae)

HERBERT B. HUNGERFORD AND RYUICHI MATSUDA[1]

Dr. Teiso Esaki described the genus *Cryptobates* for *Gerris raja* Distant (Ann. Mag. Nat. Hist. Ser. 10, 4:412-415, 1929). He also gave a redescription of *Cryptobates raja* (Distant) and drawings of an apterous male and a macropterous female. The species described below is the second species to be assigned to this genus.

*Cryptobates kuiterti* sp. nov.

*Size*: Apterous male holotype: Length 2.10 mm.; width across mesoacetabula 0.90 mm. Apterous female allotype: Length 2.42 mm.; width across mesoacetabula 1.16 mm.

*Color*: Dorsum black with pale yellowish areas as indicated on plate 1. Venter and pleuron frosty white, mesosternum with black stripes in male.

[1] Contribution No. 994, Department of Entomology, University of Kansas. This is a by-product of a project supported by a grant from the National Science Foundation.

Mesopleuron has iridescent blue sheen under certain light, with two broad black longitudinal bands, the dorsal one separated from black margin of mesonotal disk by a narrow frosty white line. Antennae and legs yellowish brown, front femur with two brown stripes.

*Structural characteristics*: Relative lengths of antennal segments in male: 1st : 2nd : 3rd : 4th :: 50 : 30 : 99 : 99. Eyes in apterous forms overlapping about one third of lateral margin of prothorax. Pronotum as long as head and not quite half as long as mesonotum. Pronotum : mesonotum :: 35 : 74 in male, 39 : 83 in female. Metanotal region in front of

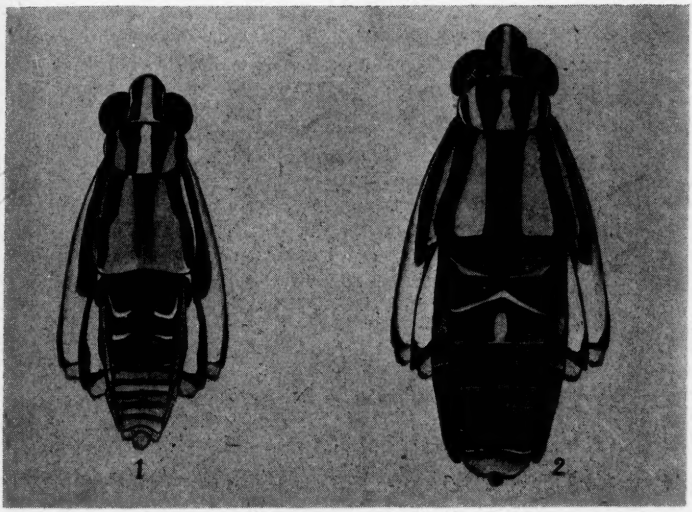


FIG. 1.—*Cryptobates kuiterti* Hungerford and Matsuda, holotype male. FIG 2.—Same species, allotype female.

anterior yellow transverse stripe elevated in female. Caudal margin of eighth abdominal tergite medially concave in both sexes. In male eighth abdominal sternite (first genital) a little longer than seventh, which is as long as two preceding segments; in female eighth abdominal sternite a little longer than two preceding segments.

TABLE 1.—The relative lengths of leg segments of male *C. kuiterti*. (The figures are micrometer units.)

| | Femur | Tibia | 1st tarsal | 2nd tarsal | Total tarsal length |
|---|---|---|---|---|---|
| Front leg | 116 | 100 | 9? | 26? | 35 |
| Middle leg | 180 | 215 | 73 | 67 | 140 |
| Hind leg | 180 | 88 | ? | ? | 57 |

Front femur slightly curved in female, more curved in male.

*Types*: Holotype male and allotype female "Shingbwiyang, Burma, March 1, 1944 (Lt. L. C. Kuitert)," preserved in the Snow Entomological Museum, University of Kansas.

*Comparative notes*: This species is much darker than *Cryptobates raja* (Distant). The median line of the pronotum is white instead of black and the black markings are wider. The antennal segments of *C. raja* (Distant)

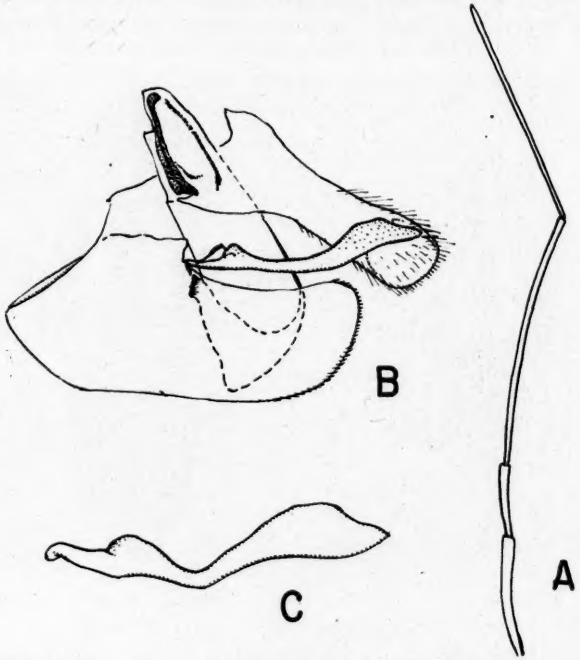


FIG. 3.—*Cryptobates raja* (Distant) from Ceylon. A. Antenna of female. B. Male ninth segment, left lateral aspect. *C*. Paramere.

were measured by Esaki as 20 : 11 : 29 : 23. In the female of a pair from Ceylon, kindly loaned to us by Dr. W. E. China of the British Museum, the antennal segments measure 97 : 60 : 138 : 128. Thus the third antennal segment is plainly longer than the fourth (Fig. 3A), whereas in our new species these segments are equal. We have also examined the genital capsule, or pygophore, of the Ceylonese male and found the paramere to be surprisingly large (Fig. 3, B, C,). While the type of *C. raja* came from Vurkalay, Travancore Coast, in the extreme southwest tip of the Indian Peninsula, we believe the Ceylonese specimens to be the same species. We figure the ninth abdominal segment of a *Cryptobates* species (*C. raja*) for the first time to show its possibilities in specific determination. *C. kuiterti* is a smaller species, the apterous male measuring 2.1 mm. long and 0.9 mm. wide, whereas the apterous male of *C. raja* is 3.5 mm. long and 1.5 mm. wide.

# THE CARPENTER BEES OF THE EASTERN PACIFIC OCEANIC ISLANDS (Hymenoptera: Apoidea)

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University of California, Berkeley

Although a number of the eastern Pacific oceanic islands seem to offer suitable environmental conditions for occupancy by at least certain species of the genus *Xylocopa*, only two of these island groups, the Galápagos Islands, situated 650 miles west of Ecuador on the equator, and the Revillagigedo Islands, located between 400 and 600 miles off the western Mexican coast near 18°N. and 112°W., have been successfully invaded by these wood nesting bees. In both of these archipelagos the genus is represented by a single species. Interestingly these species, as well as the Hawaiian Islands adventive, belong to the Neotropical subgenus *Neoxylocopa* Michener. All three species appear to have successfully established themselves within historic times, though very possibly *Xylocopa darwini* Cockerell of the Galápagos Islands may have become adventive much earlier. It is curious that no species belonging to the other New World subgenera of the genus *Xylocopa* are known from any of the islands of the eastern Pacific, including the continental islands.

More than 150 species of the chiefly tropicopolitan genus *Xylocopa* have been described from the New World. The majority of these are recorded from tropical South America, where in Brazil no less than 70 species have been reported. To the north and south of the American tropics the numbers of species progressively decrease until in the north and south temperate regions of the Americas only a few species are present. Thus in America north of México there are but seven recognized species, one of which, *Xylocopa* (*Xylocopoides*) *virginica* (Linnaeus), occurs as far north as latitude 45°N. in southeastern Canada and northeastern United States (Hurd, 1955: map 1). A comparable number of species occur in the temperate region of South America, and interestingly one species, *Xylocopa* (*Schönherria*) *splendidula* Lepeletier, is recorded from as far south as the State of Chubut, Argentina, near latitude 45°S. (Brèthes, 1916:418). A number of species belonging to several subgenera and including several endemic forms are also known from the West Indies.

The failure of the genus *Xylocopa* to colonize more than the two aforementioned oceanic archipelagos of the eastern Pacific may simply be due to the relatively great dispersal distances involved. With the assistance of man, however, at least one continental American species evidently traversed more than 2,000 miles of the Pacific Ocean and became successfully established in the Hawaiian Islands. Quite clearly the barrier is no longer an insuperable one, even though there is no direct evidence of when and precisely how this dispersal was accomplished. That bee, currently regarded as *Xylocopa brasilianorum sonorina* Smith (Lieftinck, 1956:72) doubtless was introduced by man (Blackburn and Kirby, 1880:85; Williams, 1927:429)

and subsequently has become successfully adventive in the Marianas Islands (Krombein, 1950:133), and possibly the same bee may have been inadvertently though unsuccessfully introduced by man into China, Japan and "Neu Holland" (Maidl, 1912:264, 312) and the United States (Hurd, 1955:35).

In contradistinction to the avenues of natural dispersal, the role man has unknowingly assumed in the dispersal and the occasional successful establishment of this wood nesting group of bees (some of which not infrequently nest in structural timbers) is more important than previously realized (Hurd, 1958). Even so, inadvertent introductions by man of potentially successful species will always be limited to a comparatively few species. Part of this limitation is already established by each carpenter bee species through its choice of nesting substrates and part by man in his somewhat selective transportation of materials likely to contain active nests of the bees. Unfortunately this very process results in the introduction of species of potential economic importance since these are the most likely to be transported in the timbers of commerce. It is anticipated that other seemingly suitable oceanic islands of the eastern Pacific will be colonized by carpenter bees of the genus *Xylocopa* in this very manner.

As will be noted in the following discussions there is no direct evidence to implicate man as being responsible for the colonization of the Galápagos and Revillagigedo Islands by these bees. In point of fact both introductions can be readily explained in terms of natural dispersal, but the indirect evidence appears to favor the unknowing intervention of man within or just prior to historic times.

*Xylocopa* (*Neoxylocopa*) *darwini* Cockerell

*Xylocopa brasilianorum,* Maidl, 1912, Ann. K. K. Naturhist. Hofmus., 26:312 (male, Galápagos Islands), *nec* Linnaeus, 1767.

*Xylocopa transitoria,* Brues, 1924, Zoologica, 5:125 (female, Galápagos Islands: South Seymour Island); Salt and Bequaert, 1929, Phyche, 36:-279; *nec* Pérez, 1901.

*Xylocopa colona,* Rohwer, 1924, Zoologica, 5:173 (female, Galápagos Islands: South Seymour Island; Tagus Cove, Albemarle Island; Conway Bay, Indefatigable Island); Williams, 1926, Proc. Calif. Acad. Sci. (4)2: 356-357 (male, female, Galápagos Islands: Albemarle, Chatham, Charles, Indefatigable, James, and South Seymour Islands); *nec* Lepeletier, 1841.

*Xylocopa darwini* Cockerell, 1926, Ann. Mag. Nat. Hist., (9)17:659-660 (female, Galápagos Islands: Chatham Island); Cheesman, 1929, Trans. Ent. Soc. London, pp. 143-144, figs. 2A, B (male, female, Galápagos Islands: Albemarle, Charles, Indefatigable, and James Islands); Cockerell, 1935, Proc. Calif. Acad. Sci., (4)21:379-382 (male, female, Galápagos Islands: Charles, Chatham, Duncan, Gardner, Indefatigable, James and South Seymour Islands).

Location of type: U. S. National Museum.

Geographic range: Endemic on Galápagos Islands.

Ecological distribution: low elevations and along sea beaches (Williams, 1926:356).

Nesting woods: Dead branches of *Bursea, Croton, Hibiscus tiliaceous* and particularly the very soft wood of *Erythrina* (Williams, 1926:356).

Parasite: *Cissites maculata* (Swederus) (Brues, 1924:125).

The female of this small species has been well characterized by Cockerell (1926:659), and the male has been described and partially illustrated by Cheesman (1929:143). It is said to be related to *X. carbonaria* Smith, a species which originally was described from Tapajós, Brazil, and subsequently recorded from Argentina, Paraguay and even México. Whether this or some other American species is the progenitor of *X. darwini* is yet to be determined. Unquestionably this endemic species was derived from the American continental *Xylocopa* fauna.

Cockerell (1935:379) has suggested that an immigrant stock can be transported in a drifting tree, and this seems to be one of the most likely explanations to account for its presence on this group of islands. If this is so, the immigrant stock must have been carried from more southern latitudes such as Perú, by the Antarctic Humboldt current. This, of course, is not impossible. However, when the faunal relationships of the Galápagos Islands are considered in the light of those of the continental areas, the faunal affinities are much closer with those of Central America. There is some evidence which suggests that the Galápagos Islands were at one time connected by a series of islands to Central America. Quite obviously it becomes all the more important to discover the putative continental progenitor of *X. darwini,* so that a more precise idea may be gained of how and approximately at what time the introduction occurred. It is equally possible with the present evidence to envision the stocking by man's inadvertence.

Cockerell (1935), noting the tendency of the species to develop insular races, evaluated the differences existing among the various island populations within the archipelago and concluded that incipient races, differing in sculpture and wing color, are evident but are too variable for precise definition. The underlying reason for this variability he believed is interisland immigration of sufficient magnitude as to preclude the development of well differentiated races.

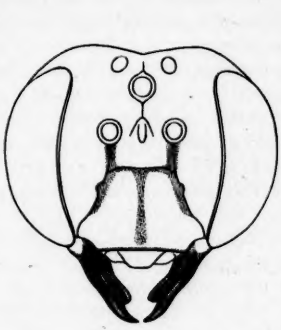
### *Xylocopa* (*Neoxylocopa*) *clarionensis* Hurd, new species

(Figures 1-4)

MALE.—Integument chiefly fulvous brown, densely clothed with tawny pubescence which pales almost to white on genae and thorax at sides. Wings subhyaline, faintly but noticeably stained with brown along costal area of forewing. Head yellow tinged with fulvous, clothed sparsely on face with short to long, mostly simple, pale golden hairs densest about and between antennal insertions and immediately above hind ocelli; hind margins of head and outer portions of genae densely clothed with long, plumose, golden yellow hairs imparting a shaggy appearance, especially to outer portions of genae and hind margins of vertex; face sparsely to moderately punctured, punctures becoming very dense and confluent on upper parocular areas and especially on lateral areas of vertex; black mark-

ings of face and mandibles as illustrated (fig. 1); antennae dark fulvous in front (almost black on first flagellar segment, but paler on scape in front, almost yellow) darkening to deep mahogany and black behind; first flagellar segment about equal in length to second and third combined; labrum bright yellow, with central portion raised in a small, nearly trapezoidal platform (fig. 1) which projects slightly forward and above labral surface so as to form a short anterior cariniform process as seen from below; relative positions of facial features as illustrated (fig. 1); frontal carina scarcely elevated, weakly cariniform, about equal in length to diameter of anterior ocellus. Thorax including propodeum largely fulvous brown above, darkening on sides and below to black, densely clothed with relatively long, plumose, somewhat pale fulvous to almost white pubescence, excepting a central, anteriorly oriented, triangular, bare impunctate area on mesonotum; tegulae bright ferruginous, impunctate or nearly so on apical two-thirds; legs fulvous brown excepting coxae, trochanters, middle and hind femora and basal portion of fore femora which are black; claws tipped on apical half with black; basitibial plate 2/5 from base; anterior wing including tegula 18 mm. Abdomen almost wholly fulvous brown, densely clothed on first metasomal tergum with mostly erect, plumose, fulvous hairs; terga 2-5 moderately punctured, except narrow, arc-like, impunctate, apical band, moderately clothed with suberect, short, fulvous hairs and a subapical fringe of paler decumbent hairs; subapical fringe hairs of fourth and fifth terga about twice as long as those on third; sixth metasomal tergum moderately punctured, except medio-apical bare area, rather densely clothed with mostly very long, suberect, fulvous hairs; seventh tergum densely clothed at base and sides with very long, posteriorly projecting, almost ferruginous hairs which appear tuft like; metasomal sterna somewhat darker than terga; metasomal sterna 1-6 each with a short medially interrupted, subapical fringe of posteriorly directed fulvous hairs. Genitalia as illustrated (figs. 2-4). Length 20 mm.

FEMALE.—Integument black, but with a pronounced reddish integumental subapical band on second, third and fourth metasomal terga and sterna of allotype (though some paratypes have it on first and fifth as well); body pubescence short, black, best expressed on face, head behind, thorax including propodeum, and abdomen at sides and apex; wings lightly infuscated throughout with areas external to closed cells appearing as a darkened band to unaided eye; wings brightly refulgent in fresh specimens, tending to become rose purple beyond cells and weakly suffused throughout with green. Head moderately to densely punctate but with small impunctate areas behind and adjacent to ocelli; genal punctures densest below and behind but with those near vertex becoming arranged in sparse, irregular rows; clypeus moderately punctate except on narrow median polished area, antero-lateral clypeal projections scarcely produced, noticeably rounded; labral tubercles three, median one, as seen from above, strongly elevated forming a high, thin flat-topped carina about equal in length to diameter of anterior ocellus, lateral labral tubercles short and broad, about as wide as malar space and with their lateral margins incurved; frontal



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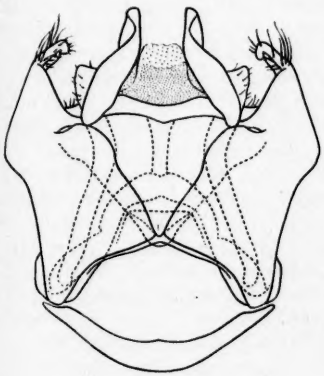

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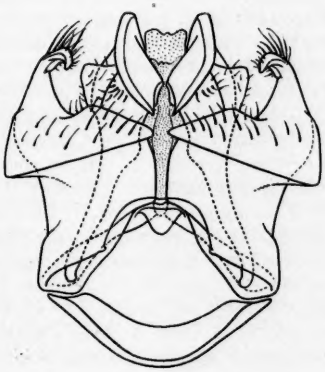

4

EXPLANATION OF FIGURES

*Xylocopa clarionensis*, male, fig. 1, anterior view of head; figs. 2-4, genitalia: fig. 2, lateral view, fig. 3, dorsal view, fig. 4, ventral view. Drawings prepared from holotype by Celeste Green, Scientific Illustrator, University of California, Berkeley.

carina projecting as a short (not exceeding anterior antennal bases), somewhat anteriorly elevated, flat-topped and highly polished, narrow carina uniting at its base with anterior ocellar basin; anterior ocellus separated from lateral ocelli by about two-thirds its diameter; hind ocellus separated from inner eye margin by more than the distance across hind ocelli; scape attaining within one anterior ocellus diameter hind margin of vertex; first flagellar segment slightly longer than combined length of second and

third flagellar segments; tegulae black, tinged on apical half with very dark mahogany red; length of forewing including tegula 18 mm.; mesonotum densely punctured in front and at sides, impunctate anteriorly on central triangular area which is glabrous and strongly shining; hind margin of mesonotum with a few scattered punctures; scutellum weakly convex, gently sloping posteriorly, not angled, clothed on apical half and at sides with numerous erect plumose hairs, anterior central half glabrous, shining and very sparingly punctured; metasomal terga densely punctured except along the narrow impunctate dull apical margins; first metasomal tergum clothed, except apically, by short plumose and simple hairs, thickest along anterior margin before declivity and at sides; metasomal terga 2-5 with a narrow, medio-longitudinal impunctate area and the surfaces, except apical margins, clothed near middle with very short, simple hairs which are somewhat longer laterally; lateral margins of terga 1-5 densely clothed with very long, posteriorly directed, plumose hairs; sixth metasomal tergum confluently punctured, clothed with very short, black hairs above, and long, posteriorly directed, plumose hairs at sides and behind; metasomal sterna with narrow, apical impunctate margin preceded by a moderately punctured subapical area which is broadly interrupted near middle; subapical fringes of simple hairs present on metasomal sterna 2-5, broadly interrupted medially with each successive sternal fringe toward apex of abdomen consisting of longer hairs; sixth metasomal sternum densely and confluently punctured except along extreme apical margin and at base. Length 20 mm.

TYPES.—Holotype male, allotype female, and 31 paratypes (3 males, 28 females) collected on Clarion Island, Revillagigedo Islands by H. H. Keifer on April 26, 27, 28, 30, and May 1, 1925. This series, together with 3 additional paratypes (2 males, 1 female) obtained at the same locality by T. Craig on February 27, 1928, are property of the California Academy of Sciences and were kindly made available for study by Mr. C. Don MacNeill of that institution. Through the courtesy of Dr. J. N. Belkin, University of California, Los Angeles, I also have had the privilege of examining one male and 42 females (all designated paratypes) taken on the same island by William A. Mac Donald and D. C. Blodget during May 7-8, 1955, and 3 female paratypes, March 1953, collected by B. H. Brattstrom.

This species is most closely related to the adjacent mainland species which is currently known as *Xylocopa brasilianorum varipuncta* Patton and very likely was derived from it. It differs most noticeably in its much smaller size, the presence of the narrow reddish integumental bands on the abdomen of the female, and in structure of the male genitalia.

Clarion Island is situated about 400 miles from the tip of Baja California, and the nearest point on the western mainland coast of México is about 600 miles. It is the most distant and the only island of the Revillagigedo Islands known to be colonized by the genus *Xylocopa*. The continental Tres Marías Islands, located approximately 70 miles west of the Méxican Pacific coast and nearly in line with the Revillagigedo Islands, are inhabited at least on Magdalena Island and Maria Madre Island by a carpenter bee which is very similar to the continental *X. brasilianorum*

*varipuncta*. At present only a few females are known, and without the male it is almost impossible to evaluate properly the characteristics of this bee.

Relying largely on morphological criteria to explain the origin of the endemic *X. clarionensis*, I am led to believe that the immigrant stock was introduced in relatively recent times. It is, however, almost a matter of pure conjecture how the original colonization was accomplished.

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Dr. Herbert B. Hungerford, University of Kansas professor emeritus of entomology and a former president of the Kansas Entomological Society has been awarded the Joseph Leidy Memorial Award medal of the Academy of Natural Sciences of Philadelphia. The medal, given every three years for the best publication, exploration, discovery or research in the natural sciences, will be presented to Dr. Hungerford Oct. 23 at a ceremony in the academy.

# NOTES ON THE HOST AND BIOLOGY OF *TETRAGONOCEPHALA FLAVA* CRAWFORD

## (Homoptera: Psyllidae)

JOHN G. RIEMANN

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Crawford in 1914 erected the genus *Tetragonocephala,* and described the species *T. flava* on the basis of a single specimen of a psyllid collected at Brownsville, Texas. By the time Tuthill's monograph on the North American psyllids was published in 1943, eight specimens of *T. flava* had been collected, five from Brownsville, two from Mexico, intercepted on produce incoming at Brownsville, and one from Arizona. Both of these authors indicated that *T. flava* appeared to be related to the hackberry gall producing genus *Pachypsylla,* but nothing was definitely known of its host or its biology. However, Ferris in 1926 described the fifth instar of an unknown species found in small wax cells on leaves of *Celtis reticulata* at Marathon, Texas. He found it had certain resemblances to nymphs of *Pachypsylla* and speculated that it might be *T. flava.* In a search of the literature the writer has found no further reference to work on this species.

Incidental to his work on hackberry galls in Texas, the author has observed, in central, south, and southwestern Texas, on both *Celtis reticulata* and *C. laevigata,* many waxy cells of a psyllid similar to those described by Ferris. They were noted to be especially numerous in the lower Rio Grande Valley, in the extreme southern part of the state. Three adults have been reared, one male (Palmetto State Park, Ottine, Texas; *C. laevigata*) and two females (Austin, Texas; *C. laevigata*). Using Crawford's and Tuthill's monographs these have been determined as being almost certainly *Tetragonocephala flava.* It is also believed that the fifth instar nymphs described by Ferris as noted above were indeed *T. flava,* as suggested by him at that time.

Very little has been established about the biology of *T. flava.* However, unlike *Pachypsylla,* it has more than one generation per year, probably two in central Texas. One of the collected specimens emerged on August 4, and a number of empty cells were noted at that time. Emergence of the last generation coincides with the autumn shedding of the host leaves, during November in central Texas.

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# REPRODUCTIVE POTENTIAL IN RELATIVELY ISOLATED HOUSE FLY[1] POPULATIONS FOLLOWING REPEATED INSECTICIDE APPLICATIONS[2]

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This study was prompted by limited observations and laboratory studies which suggested that possible changes in reproductive potential and certain other biological characteristics may occur in a field insect population following repeated exposure to insecticides.

Knutson (1955) reviewed some literature on effects of sublethal insecticidal exposures, primarily inorganic poisons, and reported on his studies with *Drosophila melanogaster* (Meigen). It was found that flies which survived one exposure to dieldrin in the laboratory at a strength sufficient to kill 66 to 99 per cent of the population, produced 5.8 per cent more adult progeny than the controls. Reproduction per female fly-day was found not to be significantly different but the treated flies lived longer and reproduction occurred over a relatively longer period.

Afifi and Knutson (1956) exposed an insecticide-susceptible laboratory strain of house flies to dieldrin at a strength to produce a 60 to 90 per cent mortality. A 16.7 per cent increase in adult progeny was attained. The $F_1$ of the treated parents produced 69.2 per cent more adult progeny than the controls but the $F_2$ and the $F_3$ of the treated parents did not produce significantly more adult offspring, indicating a reversion to near normalcy. No significant difference occurred between the length of life of the treated and untreated females. The same was true when comparing relative length of oviposition period. Relative weights were likewise not significantly different in the parent and $F_3$ generations, but in the $F_2$ generation the treated group was significantly heavier. Ouye and Knutson (1957) found this same insecticide-susceptible laboratory strain to produce 12 per cent more adult offspring following treatment with malathion in the larval medium.

Metcalf (1955) summarized results of various workers involving various strains of house flies with various degrees of resistance developed independently, and concluded "There is little evidence of positive correlation between the factors responsible for biotic potential or vigor and specific insecticide resistance."

Knapp and Knutson (1957) found the adult progeny of one somewhat geographically isolated insecticide-susceptible field population of house flies to be less than half that of another. They thus showed natural differences

[1] *Musca domestica* L.

[2] This investigation supported in part by the Research and Development Division, Office of the Surgeon General, Department of the Army, under Contract No. DA-49-007-MD-560. Contribution No. 704, Department of Entomology, Kansas Agricultural Experiment Station, Manhattan. Suggestions of Dr. C. C. Roan are gratefully acknowledged.

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between field populations, independent of insecticide resistance. Still greater differences were exhibited when even the more productive of these two field populations was shown to have a reproductive potential of less than one-fifth of that of a laboratory-reared insecticide-susceptible strain (Ouye and Knutson, 1957).

The study reported herein, on the other hand, has involved measurement of biological changes following consecutive insecticidal treatments and development of resistance in only one field population.

## MATERIALS AND METHODS

A relatively isolated (geographically) breeding area was selected in order that the fly population would be more intact and migration into and out of the area would be minimized. An isolated ranch in the "Flint Hills" region, largely blue stem grass pasture, twelve miles southeast of Manhattan, Kansas, was found several miles from the nearest known fly breeding area. No applications of chlorinated or organic phosphorous insecticides had been made during previous years, with the possible exception of some methoxychlor sprayed directly upon cattle several years previously. There was no record of residual spraying, and the $LD_{50}$ was determined to be 3.0 $\mu$g. per fly by topical application of DDT. This indicated no resistance when compared with an $LD_{50}$ of 3.0 in the KUN non-resistant strain maintained in the Department of Entomology laboratory, Kansas Agricultural Experiment Station.

Since direct measurement of comparative progeny production of the flies collected in the field was impossible because of age differences, comparison was made of their subsequent generation reared in the laboratory at a constant temperature of 80° ± 2° F.

Collections made prior to the first spraying on July 2, 1954, constituted the untreated "OT" population. Potential breeding areas on the ranch were then sprayed on July 2 and again on July 9, 1954. The spray consisted of a 15 per cent dieldrin emulsion concentrate, diluted with water to one-half per cent, sprayed as a residual spray on virtually all fly resting surfaces on the ranch and on breeding areas in the barn and poultry house and other favorable areas. A subsequent collection of adults was made on July 12, 1954, which constituted the "1T" population. The second set of sprayings was made on July 31 and August 5, 1954, followed by fly collections on August 10, which constituted the "2T" population. Details of rearing and handling techniques of the 1T and 2T groups were described by Afifi and Knutson (1956). Group collection samplings consisted of ten males and ten females placed in the oviposition jars, replicated twenty-two times.

The third collection was made the following spring, on June 8, 1955. This was the "2Tw", which was the "2T" group following overwintering. A third spraying occurred on June 20, 1955, followed by a collection on July 6 which composed the "3T" group. A fourth spraying was made on July 22, 1955, to produce the "4T" group, but there was no subsequent population sample of this group during the remainder of the year because of enormous reduction in numbers of flies as the result of insecticidal action which, in combination with the hot, dry weather and reduced breeding

areas, resulted in insufficient flies for sampling purposes. During 1955, additional population samples consisting of thirty females from each population were placed individually in rearing cages, with two males per female, in order to determine the relative productivity of individual females. Daily records of longevity, egg production, and pupa and adult survival were maintained throughout their life span. Work during 1954 and 1955 was done primarily by the second author.

A sample of overwintered "4T" flies was made on June 21, 1956, designated "4Tw". A fifth spraying was made on July 6, 1956. All breeding and resting places were sprayed with a one-half per cent dieldrin wettable powder spray. Observations made five days later showed an enormous reduction in fly population. A subsequent collection of flies on August 8 was designated "5T." During 1956, much larger samplings of flies were used and the work was done principally by the third author. Approximately 2,300 females were collected during each sampling and were mass-reared for one generation for increase. Population samples consisted of thirteen replications of 500 males and 500 females for each group. Techniques and statistical analysis used were identical to those described by Ouye and Knutson (1957). Longevity was based upon per cent survival, i.e., the actual number of females remaining alive each day divided by the original number. Daily egg production was determined by volumetrically measuring them (0.3 cc. = 2,000 eggs ± 180), after which the eggs from all replicated cages were thoroughly mixed. To determine hatchability, 600 eggs were removed daily and percentage of hatching recorded at forty-eight hours. To determine pupation and emergence, approximately 2,000 eggs were taken daily from the same batch of mixed eggs as used in the hatchability determinations. These were planted in CSMA medium, one plant each day. Pupae were subsequently counted and then transferred to cages and the resulting flies counted. Weights were determined by using the same techniques as described by Ouye and Knutson (1957). Data were based on the first twenty-eight days following initial oviposition because egg production was almost negligible thereafter.

## RESULTS

Over-all results for the three years are given in Table 1. The resistance to dieldrin increased throughout the three years, although there was a drop following each of the two overwinterings. The number of adults per female parent decreased following the 1954-55 overwintering but returned to the former level following the third spraying in 1955 and remained at the same approximate level following overwintering in 1955-56. It dropped to a new low following the fifth spraying of 1956. Percentage of survival from egg to pupa, pupa to adult, and egg to adult, not measured the first year, followed much the same pattern as the resistance during the second and third years, except that there was a marked reduction following the fifth spraying in 1956. Longevity followed the same pattern as survival except that (1) during 1954 it was longer following the first spraying, and (2) it dropped off less following the fifth spraying of 1956, compared to the population following the overwintering of 1955-56.

TABLE I.—Certain biological characteristics of flies collected at a geographically isolated ranch following successive applications of dieldrin, Riley Co., Kansas.

| | 1954 | | | | | | 1955 | | | | | | 1956 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-spray July 2 "0T"[a] | | 1st spray July 2-9, collected July 12 "1T" | | 2nd spray July 31-Aug. 5, collected Aug. 10 "2T" | | 2nd spray (overwintering) collected June 8 "2Tw" | | 3rd spray June 20, collected July 6 "3T" | | Overwintering following 4th spray, collected June 21 "4Tw" | | 5th spray July 6, collected Aug. 8 "5T" | |
| $LD_{50}$ (males) $\mu$g. per g. | 2.15 | | 2.48 | | 3.46 | | 2.76 | | 9.7 | | 4.14 | | 96.98 | | | |
| Adults per ♀ | 35.6 | ≅ | 42.0 | ≅ | 37.8 | ** | 15.1 | ** | 40.0 | ≅ | 43.8 | * | 21.7 | | | |
| % survival | | | | | | | | | | | | | | | | |
| egg to pupa | ..... | | ..... | | ..... | | 35.0 | * | 71.4 | * | 21.4 | * | 15.3 | | | |
| pupa to adult | ..... | | ..... | | ..... | | 92.6 | * | 96.8 | * | 79.4 | * | 51.3 | | | |
| egg to adult | ..... | | ..... | | ..... | | 32.2 | * | 69.1 | * | 16.5 | * | 7.8 | | | |
| Average longevity (days) | 19.0 | * | 19.2 | * | 19.0 | | 17.1 | * | 21.5 | * | 15.7 | ≅ | 14.7 | | | |
| Dry weight $\mu$g. per ♀ adult | ..... | | ..... | | ..... | | 3.7 | * | 4.0 | * | 3.8 | * | 4.0 | | | |

* Significant at 5% level
** Significant at 1% level
≅ Approximately equal
[a] 0—no treatment, 1T—1 treatment, 2Tw—overwintering following 2 treatments, etc.

Weight, which was not measured in terms of dry weight the first year, followed the same pattern, except that it again increased following the fifth spraying of 1956.

Table 2 summarizes the 1956 results in more detail.

Over-all egg production was significantly greater only during the first ten days of the 4Tw parents' lives. Total egg production (278 vs. 250 per ♀) was approximately equal.

Longevity in Table 2, expressed in terms of per cent survival, was approximately equal, statistically, but slightly greater at the end of each week in the 4Tw (58.1 vs. 52.4 per cent at end of four weeks).

In summary, the 4Tw flies laid more eggs to some extent during the first ten days of life as a result of greater longevity (female-fly days) as well as eggs per female-fly day. This difference in egg production subsequently disappeared almost completely, as a result of an increase in eggs per female-fly day in the 5T.

Hatchability, pupation and adult emergence (Table 2) were based upon a constant number of eggs for both populations and therefore reflect only the relative survival after egg production between life history stages. Hatchability in the 4Tw was greater during the first week and less during the fourth week, but approximately equal during the second and third weeks. Total hatchability was approximately equal (71.9 vs. 72.6 per cent).

Survival between hatched larvae and pupae and between pupae and adults and between eggs and adults was always greater in the 4Tw than in the 5T.

Production of potential adult progeny per female was greater in the 4Tw at the end of the first week (15.3 vs. 3.0) as a result of a somewhat greater longevity of parent females in combination with a greater number of eggs per female-fly day and a greater survival from egg to adult (17.8 vs. 5.7 per cent). At the end of the second week the 4Tw was again greater, but the difference in potential adult progeny was reduced (19.6 vs. 14.0) because of approximately equal egg production (135 vs. 137) in combination with a reduction in difference in survival from egg to adult (14.5 vs. 10.2 per cent). The same occurred during the third and fourth weeks, although with less influence upon total adult progeny production because of the relatively few eggs laid during the last two weeks (21 per cent and 24 per cent of the total, respectively). The total adult progeny of the 5T was less than half that of the 4Tw (21.7 vs. 43.8 adult progeny per female parent).

## DISCUSSION

A comparison of reproductive potential and other biological changes obtained in (1) this study, (2) between two relatively isolated, insecticide-susceptible, field populations (Knapp and Knutson, 1958), and (3) an insecticide-susceptible laboratory-reared population and the results following malathion treatment as larvae (Ouye and Knutson, 1957) is given in Table 3. Only the period of major progeny production (first fourteen to eighteen days of parents' lives) is given, since averages during this period more nearly reflect the major differences, than if the less productive remaining days of the parents' lives were included.

TABLE 2.—Reproductive potential and longevity of flies collected in spring following 4 dieldrin treatments during 2 previous years (4Tw) and following a fifth spraying (5T), Riley, Co., Kansas. 1956.

| Successive period, days | | Egg Production | | Longevity | Hatchability[a] | Pupation[a] | Adult Emergence[a] | | Potential adult progeny |
|---|---|---|---|---|---|---|---|---|---|
| | | per ♀ | per cent total eggs each 7 days | per cent survival, actual over original, cumulative ♀-fly days | per cent eggs that hatched | per cent larvae that pupated | per cent pupae that emerged | per cent survival from eggs | per ♀[b] |
| 1-7 | 4Tw | 86 | 31 | 88.3 | 89.0 | 26.9 | 74.5 | 17.8 | 15.3 |
| | | * | | ≅ | * | * | * | * | * |
| | 5T | 53 | 21 | 84.1 | 80.0 | 20.9 | 34.1 | 5.7 | 3.0 |
| 8-14 | 4Tw | 135 | 48 | 82.2 | 75.8 | 23.2 | 82.3 | 14.5 | 19.6 |
| | | ≅[c] | | ≅ | ≅ | * | * | * | * |
| | 5T | 137 | 55 | 77.6 | 76.7 | 21.3 | 62.6 | 10.2 | 14.0 |
| 15-21 | 4Tw | 48 | 18 | 70.9 | 64.2 | 28.8 | 81.6 | 15.1 | 7.2 |
| | | ≅ | | ≅ | ≅ | * | * | * | * |
| | 5T | 53 | 21 | 66.9 | 66.0 | 22.9 | 52.3 | 7.9 | 4.2 |
| 22-28 | 4Tw | 9 | 3 | 58.1 | 58.7 | 40.0 | 79.1 | 18.6 | 1.7 |
| | | ≅ | | ≅ | * | * | * | * | * |
| | 5T | 7 | 3 | 52.4 | 67.8 | 19.2 | 56.2 | 7.3 | 0.5 |
| Total | 4Tw | 278 | | | 71.9 | 29.7 | 79.4 | | 43.8 |
| | | ≅ | | | ≅ | * | * | | * |
| | 5T | 250 | | | 72.6 | 21.1 | 51.3 | | 21.7 |

* Significant at 5% level
≅ Approximately equal.
[a] Percentages based upon a constant number of eggs
[b] Egg production × per cent survival of adults from eggs
[c] 4Tw greater through tenth day

TABLE 3.—Summary of average reproductive potential and longevity of certain populations of house flies during the period of major progeny production (14 to 18 days). Riley Co.: OT—no treatment; 4Tw and 5T indicate collections on same ranch following four sprayings over a two-year period, the 4Tw during spring and the 5T following a fifth spraying, see Table 2. KUN is insecticide-susceptible laboratory population; KUT is KUN population following larval treatments with malathion (Ouye and Knutson, 1957). Ellsworth and Wilmore populations are two field-collected, relatively geographically isolated, insecticide-susceptible populations (Knapp and Knutson, 1958).

| Treatments | Resistance to: (μg. per g.) flies | | Eggs per ♀ parent | Longevity per cent survival, actual over theoretical, cumulative ♀-fly days | Hatchability[a] per cent eggs that hatched | Pupation[a] per cent hatched larvae that pupated | Adult emergence[a] | | Adult progeny per ♀[b] |
|---|---|---|---|---|---|---|---|---|---|
| | DDT | Dieldrin | | | | | per cent pupae that emerged | per cent survival from eggs | |
| Field populations: | | | | | | | | | |
| Riley Co. OT | 3.0 | 2.15 | ..... | ..... | .... | .... | .... | .... | 35.6 |
| Riley Co. 4Tw | | 4.14 | 221 | 82.2 | 82 | 25 | 78 | 16 | 34.9 |
| Riley Co. 5T | | 96.98 | 190 | 77.6 | 78 | 21 | 48 | 8 | 17.0 |
| Ellsworth | 3.7 | | 275 | 88.2 | 77 | 16 | 62 | 8 | 22.2 |
| Wilmore | 2.7 | | 256 | 80.7 | 79 | 31 | 75 | 18 | 47.9 |
| Laboratory populations: | | | | | | | | | |
| KUN | 3.0 | | 314 | 77.8 | 79 | 85 | 91 | 61 | 179.6[c] |
| KUT | 3.0 | | 292 | 72.6 | 79 | 89 | 91 | 68 | 226.6[c] |

[a] Percentages are averages of 2 seven- to nine-day periods, totaling 14 to 18 days.
[b] Percentages taken directly from original data rather than calculated from less accurate averages of 2 periods.
[c] Difference not as great at end of 3 weeks, because of relatively high production of KUN during third week.

Eggs per female averaged from 190 to 275 among the field populations, with the insecticide-resistant (5T) the lowest (190). The normal and the treated laboratory populations (KUN and KUT) averaged significantly more eggs per female (314 and 292) than the field populations. Longevity, based on per cent survival in terms of female-fly days, averaged from 77.6 to 88.2 per cent among the field populations, with the insecticide-resistant (5T) averaging the lowest (77.6%). The normal laboratory population (KUN, 77.8%) averaged approximately equal to the insecticide-resistant field population (5T, 77.6%), while that of the treated laboratory population averaged lower (KUT, 72.6%). Hatchability averaged from 79 to 82 per cent among the various field and laboratory populations. Pupation from hatched larvae among the field populations averaged from 16 to 31 per cent with one of the insecticide-susceptible field populations the lowest (Ellsworth); the untreated and treated laboratory populations averaged much higher (85 and 89%). Percentage of adult emergence from pupae among the field populations averaged from 48 to 78 per cent with the insecticide-resistant field strain the lowest (48%). The untreated and treated laboratory strains had a distinctly higher average percentage (91%). Survival from egg to adult averaged from 8 to 18 per cent among the field populations with the lowest in one insecticide-susceptible and the insecticide-resistant (8%), while the average for the untreated and treated laboratory strains was much higher (61 and 68%). The number of adults per female parent in the field populations averaged from 17.0 to 47.9, being lowest in the insecticide-resistant population (17.0); this represented a reduction of more than 50 per cent as compared to production prior to initiation of spraying (OT vs. 5T). This compared to 179.6 and 226.6 adult progeny per female in the untreated and treated laboratory populations, respectively.

All studies except the original Riley County (OT) were done concurrently, using the same rearing conditions and the same batches of rearing media and the same technical assistance. Crowding effect was also eliminated as a factor by preliminary tests which showed the rearing containers large enough not to interfere with normal development.

Outstanding differences between the laboratory population and among field populations are shown. Granting that some of this difference between laboratory and field populations may be the result of change in food and environment when the field populations were brought into the laboratory, nevertheless, the innate differences between them and the laboratory population, which probably had undergone selection and was reared under ideal conditions as compared to the field populations, is demonstrated. The reduction in reproductive potential of the one field population studied as it underwent progressive insecticide resistance is also shown. But it must be emphasized that, because of the innate differences in various populations, the results obtained in this study may apply only to the populations studied, and cannot necessarily be expected to apply to other populations. The investigator of biology and control must realize that striking innate differences in reproductive potentials among populations do exist, and that these vary with respect to eggs laid, as well as to survival among the various life history stages. With a variation from hatched larvae to pupa ranging from 16 to 89

per cent, the difference in control tests to be expected in the use of larvicides, assuming the same percentage susceptibility of larvae among the populations to a given larvicide, is apparent. By the same token, control tests can be expected to vary considerably when the number of adult progeny per female during the major portion of productive life varies from 17.0 to 47.9 among susceptible and resistant field populations studied and 179.6 to 226.6 in laboratory populations studied.

SUMMARY

A somewhat geographically isolated ranch, on which virtually no chlorinated or organic phosphorous insecticides had been used, was sprayed with dieldrin twice in 1954, twice in 1955, and once in 1956. Comparisons were made between a prespray adult collection (OT), collections following each of two 1954 sprayings (1T, 2T), a collection made following overwintering of the 2T (2Tw), a collection following a third spraying in 1955 (3T), a collection made early in 1956 of the overwintering population following a fourth spraying in 1955 (4Tw), and a collection following a fifth spraying in 1956 (5T).

Resistance to dieldrin increased throughout the three years, but dropped following each of the 2 overwinterings. The reproductive potential was generally unchanged the first and second years, but dropped off the third year following the fifth spraying. Adults collected following overwintering between the first and second years had a lower reproductive potential. Adult longevity followed the same pattern except that during the first year it was longer following the first spraying, and the reduction following the fifth spraying of the third year was not as great.

A more detailed study, comparing the population collected early in 1956 following overwintering (4Tw) with the same population collected following the fifth spraying in 1956 (5T) revealed that the overwintering group produced more eggs during the first 10 days although the total egg production for the entire life span was approximately equal. Longevity was always slightly greater in the overwintering population. Hatchability during the first week was greater in the overwintering population. Superiority during adult life by the overwintering population in (1) egg production during the first 10 days, (2) hatchability during the first week, and (3) pupation and adult emergence throughout the life span, resulted in a 5T adult progeny production of less than half that of the 4Tw.

A discussion is presented, comparing results of this study with biological changes obtained previously (1) in two relatively isolated, insecticide-susceptible field populations and (2) an insecticide-susceptible laboratory-reared strain before and after malathion treatment as larvae. Egg production was lower in the field populations and lowest in the highly insecticide-resistant population, as compared to the laboratory-reared populations. Longevity was generally greater in the field populations with the lowest, the highly insecticide-resistant, being about equal to the treated laboratory-reared population. Hatchability between field and laboratory-reared populations was about equal. Per cent pupation from hatched larvae among the field populations was lowest in the insecticide-resistant population and generally much

lower than in the laboratory-reared populations. The same was true to a lesser degree in survival from pupa to adult. Over-all survival from egg to adult was much lower in the field populations, being lowest in one insecticide-susceptible and in the insecticide-resistant populations. The number of adults per female parent was much lower in the field populations and was lowest in the insecticide-resistant populations, as compared to the laboratory-reared populations.

Results emphasize major innate differences in reproductive potential between field and laboratory-reared populations, both insecticide-susceptible and resistant, and changes that can occur following insecticide treatments or overwintering. These differences include those of survival of the various life history stages. Consequently, control measures may be expected to vary in effectiveness, not only because of over-all differences in reproductive potential between populations, but also because of differences in reproductive potential at a particular stage of the life cycle at which the insecticide is being directed, as well as the season of the year at which the insecticide is being applied.

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# NOTES ON THE NORTH AND CENTRAL AMERICAN BEES OF THE GENUS *SVASTRA* HOLMBERG (Hymenoptera: Apidae)

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Since part 1 of the revision of the North and Central American bees of the genus *Melissodes* (LaBerge, 1956) was written, two of the subgenera treated therein, *Epimelissodes* and *Brachymelissodes,* have been removed from the genus *Melissodes* and placed in the genus *Svastra* (Michener, LaBerge and Moure, 1955; Moure and Michener, 1955; and La Berge, 1957). Additional specimens of a number of the less well-known species of these two subgenera, including the undescribed female of one species and a new species from Central America, have come to the attention of the author. Therefore, it seems worthwhile at this time to present these notes, together with appropriate descriptions and revisions of the keys to the species in-

volved. The reader is referred to LaBerge (1956) for an explanation of the descriptive methodology followed below and for more complete keys to the species of the subgenera *Brachymelissodes* and *Epimelissodes*.

The author is grateful to the Society of the Sigma Xi for a grant-in-aid which made possible a visit to certain European museums for the purpose of studying the types of some of the species discussed below. Also, the author is indebted to the following persons for permitting him to study specimens in their care: Dr. P. D. Hurd, The University of California, Berkeley; Dr. G. D. Butler, The University of Arizona, Tucson; Dr. R. M. Bohart, The University of California, Davis; Dr. E. S. Ross, the California Academy of Science, San Francisco; Dr. C. D. Michener, the University of Kansas, Lawrence; Dr. G. Steinbach, the Zoologische Institute Museum, Berlin, Germany; Dr. I. H. H. Yarrow, the British Museum (Natural History), London, England; Dr. M. A. Cazier, the American Museum of Natural History, New York City.

*Svastra* (*Brachymelissodes*) *cressonii* (Dalla Torre), new combination

A single male of this species, collected in Hamburg, Iowa, July 24, 1956, by Keith L. Rhodebeck, significantly extends the known range to the northeast.

*Svastra (Epimelissodes) albocollaris* (Cockerell), new combination

This species has previously been known from only six males, including the holotype. The female is described below, and additional records are cited. The female is not included in the key to the species of *Epimelissodes* (LaBerge, 1956, p. 936). However, if the first couplet of this key is revised and additional couplets are added to the end of the key, *S. albocollaris*, as well as *S. friesei* which is described below, can be readily separated from all other species. The revised couplet is as follows:

1. Scopal hairs all or almost all pale in color ..... 2
   Scopal hairs all or almost all black or dark brown, or at least brown medially on both tibia and basitarsi ..... 14

Couplets 2 through 13 remain unchanged and the key continues as follows:

14(1). Scopal hairs with few branches and with rachises of hairs extending considerably beyond plumose part so as to form what appears to be a layer of simple guard hairs covering scopae; hairs of mesoscutum and scutellum all or mostly pale ochraceous ..... *atripes*
   Scopal hairs highly plumose, rachises not extending much beyond plumose part of hairs; hairs of mesoscutum and scutellum often all or mostly black or dark brown, if not all dark, metascutal patch of dark hairs twice as large as scutellar dark patch or almost so ..... 15

15(14). Mesoscutum with hairs of anterior fifth ochraceous to pale fulvous in color; wing membranes slightly infumate; metasomal terga 5 and 6 with pale brown to orange hairs ..... *friesei*
   Mesoscutum with hairs of anterior fifth white, if pale; wing membranes deeply infumate, black to dark brown; metasomal terga 5 and 6 with black or dark brown hairs .... *albocollaris*

*Description of female*: Measurements and ratios: N, 1; length about 16 mm.; width about 6 mm.; wing length, about 5.30 mm.; hooks in hamulus, 16; length of flagellar segment 1/segment 2, 2.29.

Structure and color: As in *S. atripes* except as follows: eyes dark gray; tegulae black; wing membranes deeply infumate, blackish-brown, veins black. Sculpturing of head and thorax as in *atripes*. Maxillary palpi 4-segmented, in ratio of 2.8:2:2:1. Metasomal tergum 1 with coarse, round, deep punctures in basal half and laterally to apical margin; apical half of tergum with minute, distinct, well-separated punctures basally but impunctate in its apical half; terga 2, 3 and 4 as in *atripes*, but minute punctures of apical areas sparser, separated mostly by 2 to 3 puncture widths.

Hair: Vestiture entirely black or dark brown except as follows: facial hairs from level of antennae down to and including labral hairs all dark, all white, or a mixture of the two; genal hairs white or at least a few white; mesoscutal hairs all black, or with a few white hairs near anterior margin, with white patches near tegulae and with a few white hairs mixed with the long black basal hairs; tergum 2 with or without short, diagonal, lateral fasciae of white pubescence (extremely narrow when present); tergum 3 with or without broad lateral fasciae of white pubescence; if present, fasciae separated by more than length of one fascia; tergum 4 with narrow to broad lateral fasciae of white pubescence, the fasciae separated medially by from slightly more to distinctly less than length of one fascia, in one specimen with white pubescence continuous across extreme margin of tergum; terga 5 and 6 without pale hairs; scopal hairs brown to black; inner surfaces of hind basitarsi with dark reddish-brown to black hairs.

*Distribution*. In addition to the six males cited previously in the literature (LaBerge, 1956), the following ten specimens, all from central and south central Mexico, have been examined:

GUERRERO: Acapulco, 3 ♂♂, 1 ♀, September, 1913, H. H. Smith. Tierra Colorado, 2 ♂♂, 2 ♀♀, October, 1913, 2000 feet altitude, H. H. Smith. Rincon, 1 ♀, October, 1913, 2800 feet altitude, H. H. Smith. JALISCO: Guadalajara (8 miles south), 1 ♀, late September, 1954, F. X. Williams. The specimens collected by H. H. Smith are in the British Museum (Natural History) and the specimen collected by F. X. Williams is in the collection of Roy R. Snelling, Turlock, California.

### *Svastra (Epimelissodes) friesei*, new species

This species from Guatemala is named in honor of the late Professor H. Friese who first recognized it as a new species and had placed a manuscript name in honor of the collector on the type specimens. In many respects this species is a link between the *albocollaris* group and the *obliqua* group of the subgenus *Epimelissodes*, as defined by LaBerge (1956), but it is most logically placed in the *albocollaris* group. The male (like *albocollaris*) has an entirely black clypeus but (like *obliqua*) has much pale hair on the thorax and abdomen. The female has dark scopal hairs (like *albocollaris*); however, these are not always entirely dark and, in addition, there is much pale hair on head, thorax, and abdomen. The female can be separated from other members of the subgenus *Epimelissodes* by use of the revised key given above under *S. albocollaris*. The male can be separated by a slight

change in the key to males as given by LaBerge (1956, p. 934). This change is as follows:

1. Clypeus entirely black ..... 13
   Clypeus all or almost all pale ..... 2

Couplets 2 through 12 remain unchanged. A thirteenth couplet is added as follows:

13(1). Pale hairs on mesoscutum abundant, ochraceous to pale ferrugineous; wing membranes slightly infumate, yellowish; metasomal terga 6 and 7 with at least some brown to orange hairs; hind basitarsi with hair of inner surfaces red to orange yellow ..... *friesei*

Pale hairs on mesoscutum sparse, white to extremely pale ochraceous; wing membranes deeply infumate, dark brown; metasomal terga 6 and 7 with hairs dark brown to black; hind basitarsi with hairs of inner surfaces dark brown to black ..... *albocollaris*

*Female*. Measurements and ratios: N, 1; length, about 13 mm.; width, about 5.5 mm.; wing length, about 4.78 mm.; hooks in hamulus, 18; flagellar segment 1/segment 2, 2.31.

Structure and color: Integument generally black; distitarsi and distal half of mandible rufescent, distal half of mandible with large golden macula; tibial spurs dark reddish brown; flagellum red below except first segment and inner part of second and third segments; eyes dark violet-gray; wing membranes moderately infumate, yellowish brown, veins dark reddish brown.

Eyes with inner margins parallel, slightly longer than width of face at upper inner angles of eyes; maxillary palpal segments in ratio of about 5:4:4:2:1 (presumably the fifth segment is not always present). Clypeus densely punctate, punctures small, round, shallow, separated by less than half a puncture width, not smaller or sparser posteromedially, surface dulled by fine, dense shagreening; supraclypeal area with small, round, scattered punctures, surface partly dulled by fine, regular tessellation. Thorax densely punctate, punctures separated by less than one puncture width and often almost confluent on mesepisterna, surfaces slightly dulled by fine, sparse shagreening; propodeum with dense, round, deep punctures separated by less than one puncture width; bottoms of punctures shiny, surface dulled by regular, fine tessellation; upper impunctate triangular area of posterior surface tessellate. Metasomal tergum 1 with basal three-fifths and to apical margin at extreme sides with large, round, shiny-bottomed punctures sepseparated mostly by half a puncture width; interband zone with minute, shallow punctures (absent near extreme apex) separated mostly by one to two puncture widths; surface moderately shiny, with extremely delicate, reticulate shagreening; tergum 2 with basal area with deep, round punctures separated mostly by half a puncture width; interband zone with minute, indistinct punctures medially (where interband zone is extremely narrow), becoming coarser and crowded laterally; apical zone with distinct, shallow punctures separated mostly by one to two puncture widths, surface shagreened as in tergum 1; tergum 3 similar to tergum 2 but interband zone

with more abundant and distinct punctures; tergum 4 similar to tergum 2 but apical area restricted to median, diamond-shaped area.

Hair: Head with pale ochraceous hairs, becoming pale ferrugineous near vertex, and abundant long, dark brown hairs on vertex between apices of compound eyes. Pale hairs of thorax pale ochraceous to pale ferrugineous (ferrugineous especially on anterior part of mesoscutum); anterior and lower half of lateral surface of mesepisternum and metepisternum and propodeum (pale above) with dark brown hairs; mesoscutal dark patch extends forward to a line at anterior margins of tegulae (with a small extension of dark hairs lateroanteriad passing in front of tegulae), twice as large scutellar dark patch; scutellum with a few pale hairs peripherally. Metasomal tergum 1 with long ochraceous hairs on lateral sixth, with short, brown hairs in median two-thirds of basal three-fifths, and minute, closely appressed, brown, simple hairs in apicomedian area; tergum 2 with pale ochraceous, mostly spatuloplumose hairs in basal area, with short brown hairs in interband zone and apical area, and pale ochraceous hairs at extreme sides (lateral oblique fasciae of white pubescence perhaps exist in some females of this species, but not in the two before the author); tergum 3 with basal hairs dark, interband zone and apical areas as in tergum 2, with lateral, oblique fasciae of short, white pubescence; tergum 4 like tergum 3, except apical area covered with white pubescence except median, diamond-shaped area of sparse, short, simple, brown hairs; terga 5 and 6 with ochraceous to orangish brown hairs; basal sterna with brown hairs, becoming progressively paler apically until last exposed sternum covered with yellowish white hairs. Hairs of legs dark brown except as follows: tarsi with inner surfaces red to reddish brown, hind tibiae with inner surfaces yellow to red, fore and middle tibiae with some pale hairs posteriorly on outer surface; scopal hairs brown in medial third and yellow laterally or all pale brown.

*Male*. Measurements and ratios: N, 1; length, about 12 mm.; width, about 5 mm.; wing length, about 4.32 mm.; hooks in hamulus, 17; flagellar segment 2/segment 1, 2.96.

Structure and color: Integument generally black, distitarsi, base of mandible, labrum and ventral surface of flagellum (except first segment) rufescent; tibial spurs and tegulae dark reddish brown to black; eyes dark brownish gray; wing membranes only slightly infumate, veins dark reddish brown.

Eyes with inner margins subparallel, diverging slightly above, in facial view about two-fifths as wide as long; maxillary palpal segments in ratio of about 2:1.5:2:1. Sculpturing as in female, with the following differences: clypeal punctures sparser, separated mostly by one to two puncture widths; mesoscutum with punctures of posteromedian area sparser, often separated by more than one puncture width, but many more crowded; metasomal tergum 1 with punctures of basal area larger, separated by one-half to one puncture width; tergum 4 with apical area restricted to median third of tergum; tergum 5 with apical half distinctly punctate. Minimum length of first flagellar segment equals about one-third of maximum length of second segment.

Male terminalia essentially as in *Svastra albocollaris* (Cockerell) (see

LaBerge, 1956, p. 1187, figs. 42-44) with the following differences: gonostylus slightly more rounded distally, but with distal width greater than basal width (as in *albocollaris*); sternum 7 with from one to three stout, simple hairs on inner angle of median plates; sternum 8 with apical hairs slightly longer.

Hair: Head with ochraceous hairs except brown hairs of vertex. Mesoscutum with ochraceous hairs, slightly rufescent anteriorly, except large posteromedial patch of brown hairs which extends laterally almost to tegulae and forward almost to a line between anterior margins of tegulae; scutellum with dark brown hairs except fringe of pale hairs; mesepisterna with anterior surfaces exposed (as in *S. obliqua*); sides of thorax with pale ochraceous hairs except brown on lower, posterior angle of mesepisternum, lower three-fifths of metepisternum, and most of lateral surface of propodeum. Metasomal tergum 1 with long pale hairs in basal three-fifths and laterally to margin, with short, simple, dark brown hairs in apical area; tergum 2 with pale ochraceous, spatuloplumose hairs basally, with short, simple, appressed, dark brown hairs in interband zone and apical area, and broad, short, oblique, lateral fasciae of white pubescence, each of which covers about one-third width of tergum; terga 3 and 4 as in tergum 2 but basal areas with hairs brown, plumose, and with white pubescent fasciae more extensive; tergum 5 as in tergum 4 but white pubescence continuous across apical area (white pubescence on all terga sparse); terga 6 and 7 with bright golden hairs; sternal hairs mostly brown, but pale ochraceous apicolaterally on each sternum. Legs with hairs ochraceous except as follows: mid and hind coxae and femora with mostly dark brown hairs; tibae with posterior surfaces with short brown hairs; tarsi with inner surfaces with yellow to red hairs.

*Type material.* Holotype male, allotype female, and one male and one female paratype from Guatemala, collected by Stoll in 1890. The holotype and allotype are in the Zoologische Museum, Berlin, Germany. The paratypes are in the Snow Entomological Museum of the University of Kansas, Lawrence, Kansas.

*Svastra* (*Epimelissodes*) *helianthelli* (Cockerell), new combination

This striking large bee was previously known from only 18 specimens (LaBerge, 1956). A total of 64 new records are listed below, which fill in the known range of the species and extend the range slightly into the state of Chihuahua, Mexico. The specimens are in the collections of the University of Arizona, Tucson, the University of California at Davis and at Berkeley, the California Academy of Sciences, San Francisco, and in the author's collection.

ARIZONA: Eloy (11 miles south), 1 ♀, 1 ♂, June 28, 1953, T. R. Heag. Flagstaff, 1 ♀, September 22, 1940, F. H. Parker. Phoenix, 1 ♂, September 13, 1934, R. H. Crandall. Roll, 2 ♀ ♀ on *Verbesina encelioides,* October 6, 1955, D. M. Tuttle. Waddell, 1 ♂ on *Helianthus* sp., August 12, 1954, G. E. Bohart and G. D. Butler; 2 ♀ ♀ on *Helianthus* sp., August 14, 1954, S. E. McGregor. Yuma, 1 ♀ and 1 ♂ on *Helianthus* sp., July 21, 1954, J. Ellington; 1 ♀, September 30, 1954, D. M. Tuttle, 2 ♀ ♀ on *Gossypium herbaceum,* October 2, 1955, D. M. Tuttle; 1 ♀ on *Helianthus* sp., October 4,

1955, D. M. Tuttle; 2 ♀♀ on *Helianthus* sp., October 13, 1955, D. M. Tuttle; 1 ♀ and 1 ♂ on *Helianthus* sp., October 17, 1955, D. M. Tuttle; 4 ♀♀ on *Helianthus* sp., October 18, 1955, D. M. Tuttle. CALIFORNIA: Indio (5 miles west), 15 ♀♀ and 8 ♂♂ on *Helianthus annuus*, July 9, 1956, P. D. Hurd and E. G. Linsley. BAJA CALIFORNIA: Mexicali, 1 ♂, June 20, 1939, E. S. Ross. CHIHUAHUA: Juarez (13 miles south), 2 ♀♀ and 15 ♂♂, August 18, 1952, E. E. Gilbert and C. D. MacNeil.

*Svastra* (*Epimelissodes*) *nitida* (LaBerge), new combination

This Mexican species was previously known only by the type material (8 specimens). Eleven females and seven males from Mexico have since been examined. These additional specimens do not vary significantly from the types, except in regard to the color of the male clypeus. In the original description (LaBerge, 1956) the clypeus is described as being ". . . lemon-yellow except for black notches at anterior tentorial pits and narrow, black, irregular area at posterior margin between anterior tentorial pits." The clypeus in the specimens recorded below is black in the posterior one-third to one-half.

NAYARIT: San Blas (5 miles east), 1 ♂, July 25, 1953, University of Kansas Mexican Expedition. OAXACA: Tehuantepec (44 miles west), 2 ♂♂, July 21, 1952, E. E. Gilbert and C. D. MacNeil. PUEBLA: Acatlán (13 miles southeast), 11 ♀♀, 4 ♂♂, July 10, 1952, E. E. Gilbert and C. D. MacNeil. The first specimen cited above is in the Snow Entomological Museum at the University of Kansas; the others are in the collection of the University of California at Berkeley and in the author's collection.

*Svastra* (*Epimelissodes*) *sila* (LaBerge), new combination

There are two additional records of this interesting desert species. One of these greatly extends the known range of the species from southeastern Arizona to Baja, California. The additional records are as follows:

ARIZONA: Portal (10 miles east), 1 ♂, September 15, 1955, C. and M. Cazier. BAJA, CALIFORNIA: San Ignacio (15 miles north), 1 ♂, September 29, 1941, Ross and Bohart. The first specimen is in the collection of the American Museum of Natural History, New York City, and the second is in the collection of the California Academy of Science, San Francisco.

*Svastra* (*Epimelissodes*) *sabinensis nubila* (LaBerge), new combination

The records listed below greatly increase the known range of this subspecies to the south in Baja, California. The specimens are in the collection of the California Academy of Science, San Francisco, and in the author's collection.

BAJA, CALIFORNIA: LaPaz (10 miles northwest), 1 ♂, October 6, 1941, Ross and Bohart. Las Animas, Sierra Laguna, 15 ♂♂, October 12, 1941, Ross and Bohart. San Pedro, 2 ♂♂, October 1, 1941, Ross and Bohart.

In addition to the species discussed above or listed by Moure and Michener (1955, p. 298), the following list includes the new combinations of names which result from the generic change mentioned in the first paragraph:

*Svastra* (*Brachymelissodes*) *minima* (LaBerge)

*Svastra* (*Epimelissodes*) *atripes atrimitra* (LaBerge)
*Svastra* (*E.*) *atripes georgica* (Cresson)
*Svastra* (*E.*) *grandissima* (Cockerell)
*Svastra* (*E.*) *aegis* (LaBerge)
*Svastra* (*E.*) *comanche* (Cresson)
*Svastra* (*E.*) *machaerantherae* (Cockerell)
*Svastra* (*E.*) *obliqua caliginosa* (Cresson)
*Svastra* (*E.*) *obliqua expurgata* (Cockerell)
*Svastra* (*E.*) *texana texana* (Cresson)
*Svastra* (*E.*) *texana eluta* (LaBerge)
*Svastra* (*E.*) *petulca suffusa* (Cockerell)
*Svastra* (*E.*) *sabinensis laterufa* (Cockerell)
*Svastra* (*E.*) *sabinensis sabinensis* (Cockerell)

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# SLEEPING HABITS OF MALES OF *HESPERAPIS* (Hymenoptera: Melittidae)

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Sleeping habits have been recorded for males of bees in several families (Schwarz, 1901; Banks, 1908; Rau, 1916; Friese, 1923; Rayment, 1935; Grassé, 1942; Mathewson and Daly, 1955; Leiftinck, 1957; Hurd and Powell, 1958; Linsley, 1958. Thus, among the species which sleep in the open, males of many panurgids curl up in the center of a flower, those of *Eucera* and certain megachilids grasp a stem with the mandibles and sleep with the body extended. *Coelioxys* orients similarly but sometimes upside down. Most anthophorids grasp a stem with the legs as well as the mandibles, with the head directed upward in some cases, downward in others. Some species regularly sleep in a solitary manner, but for most there is a tendency to form aggregations varying from a few individuals among most anthophorids to several hundred in such groups as *Nomia*, eucerine anthophorids, and Australian colletids.[1]

[1] P. D. Hurd, Jr. collected an aggregation of a more specialized colletid (*Colletes clypeonitens* Swenk) sleeping on a branch of *Larrea glutinosa* at Borego, San Diego Co., California, on April 2, 1953. The group was in the form of a ball and consisted of 47 male *Colletes* and 8 individuals of *Epeolus mesillae palmarum* Linsley. We observed similar balls of *Colletes salicicola* Cockerell on various desert shrubs at Furnace Creek, Death Valley, California, on April 1, 1951, but no parasitic bees were involved.

Apparently, sleeping habits have not been recorded previously for the genus *Hesperapis*. During May and June 1958 we had the opportunity of observing sleeping males of three species of *Hesperapis* (*Panurgomia*), the females of which collect pollen from Onagraceae, notably *Clarkia unguiculata*. On May 13, at 5:00 a.m. PST, in the sand dunes near Antioch, Contra Costa Co., California, hundreds of males of an undescribed species of *Hesperapis* (*Panurgomia*) were found sleeping in large, white, day old flowers of *Oenothera deltoides* var. *howellii*. Many were sleeping singly but the majority were in groups of from two to five, often crowded deep in the corolla or on the pistil. By 7:02 a.m. the first of these was flying, and by 7:55 a.m. most individuals were actively searching for females about the flowers and over nesting areas. The numbers at this time appeared to be larger than the flower sleeping population, suggesting that alternative sleeping habits may also be involved. The first females appeared at about 8:30 a.m., at which time mating occurred (in one carefully observed case this took place in an *Oenothera* flower as the female was seeking nectar and lasted for slightly over three minutes). Males also patrolled *Clarkia unguiculata* flowers where females were taking pollen.

On May 15 at 4:00 p.m., males of a related species, *H.* (*P.*) *regularis* Cresson, at Arroyo Seco, Monterey Co., Calif., were beginning to settle for sleep on plant stems and in partially closed flowers of *Clarkia speciosa*. On stems they oriented crosswise, hanging on with all the legs; in the flowers they remained with the head at the opening. On the following morning the sun rose at 4:58 a.m. but did not actually reach the flowers until 6:32 a.m. By 7:30 males were beginning to crawl about, and at 7:39 a few were flying. By 8:35 a.m. practically all were in flight. Approximately the same observations were duplicated at the Pinnacles, San Benito Co., California, on May 17, where the females began taking pollen from *Clarkia unguiculata* at 9:15 a.m.

A third species, with very similar habits, was found associated with *Clarkia speciosa,* 6 mi. northeast of Santa Margarita, San Luis Obispo Co., California, on June 11. Females were gathering pollen in the morning, the males settling for sleep at about 3:00 p.m.

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# A NEW SPECIES AND A NEW RECORD OF HETEROTHRIPS FROM KANSAS (Thysanoptera: Heterothripidae)

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Ordinarily each species of *Heterothrips* occurs on a different kind or group of plants. As Bailey and Cott (1954) have noted, however, several species may occasionally drift as adults to hosts occupied by another species of *Heterothrips*. The two species treated herein are of interest, therefore, because in one instance they were collected together from the same clusters of flowers of *Houstonia nigricans* (L.). Adults of both sexes of these two were found exclusively on *Houstonia* in a one hour search of various flowers then in bloom on a high prairie near Sylvan Grove, Kansas. Morphologically the two are quite far apart, *Heterothrips eversi* new species belonging to Group II of the genus and *H. gillettei* Moulton belonging to Group I.

The new species is named in honor of Dr. Robert A. Evers, botanist at the Illinois Natural History Survey, my companion on this and other trips, on which occasions he has been responsible for the discovery of many interesting thrips and for the determinations of the host plants.

## *Heterothrips eversi* new species

*Female* (macropterous).—Length, distended, about 1.2 mm. Color generally dark brown. Antennal segment III predominantly yellow, being lightest at base grading into light yellowish brown at apex; segment IV yellowish brown at base and at band of sensoria. Fore femora along most of inner margin, mid and hind femora at extreme apex, and all tarsi, yellow. Fore wings medium brown except for a lighter area above and apicad of scale. Head, antennae, and thorax with orange-red subintegumental pigment.

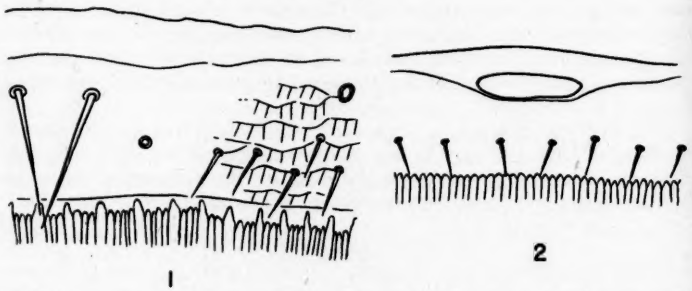
Head about 1.4 times as wide as long. Antennae similar to those of *aesculi*; segment III moderately long with dorsal sensoria arranged in one or two rows; segment IV much shorter than III, with dorsal sensoria arranged in two or three rows; segment IX subequal in length to segment VIII, not longer than segment VIII as in *lyoniae*.

Pronotum weakly sculpured with fairly widely spaced transverse striae, occasionally connected to form reticulate designs, interspersed with small setae. Metanotum with striations concentric, typical of the genus. Fore wings, as based on five individuals, each with fore vein bearing 25 to 32 setae, hind vein bearing 17 to 23 setae.

Abdominal tergites I to VII with many microsetae on lateral surfaces; tergites I to V with posterior fringe setae confined to the lateral portions, except for two to four median setae; tergites VI to VIII with entire posterior margin fringed with setae. These posterior setae usually grouped in series of four or five and fused at their bases into comb plates, which are much shorter than the length of the free, unfused section of the setae,

fig. 1. Most abdominal sternites with the entire posterior margin bearing fringe setae, the comb plates shorter than the dorsal plates. Abdominal segment X not especially elongate.

*Male* (macropterous).—Length, distended, about 1 mm. Color and structure similar to female. Fore wings, as based on two individuals, each with fore vein bearing 24 to 27 setae, hind vein bearing 17 to 19 setae. Abdominal tergite VI, unlike female, without posterior fringe setae medially, except for three setae at the mid line. Abdominal comb plates much shorter than those of the female. Abdominal sternites III to VIII each with a moderate-sized, elliptical glandular area, fig. 2; these areas grading from the smallest on sternite III to the largest on sternite VIII. Abdominal tergite IX without finger-like processes.




*Heterothrips eversi* n. sp. Fig. 1. Female, abdominal tergite VI, right median portion. Fig. 2. Male, abdominal sternite IV, median portion showing glandular area.

*Holotype.*—Female; Manhattan, Kansas; June 24, 1957; Evers and Stannard; in flowers of *Houstonia nigricans* (L.). *Allotype.*—Male; same data as for holotype. *Paratypes.*—2 females; same data as for holotype. 4 females, 1 male; Sylvan Grove, Lincoln County, Kansas; June 24, 1957; Evers and Stannard; in flowers of *Houstonia nigricans* (L.). Types deposited in the collection of the Illinois Natural History Survey.

This species is apparently similar to *vernus* Hood, which is known to me solely from its description. On the basis of characteristics of the male, at least, the two seem to be easily distinguishable. In *vernus,* according to Hood (1939), the glandular areas are minute, and the posterior abdominal fringe setae are not fused at the base into comb plates. By contrast, in *eversi* the glandular areas are moderate in size (certainly not minute) and the posterior fringe setae are fused at the base into comb plates.

The apparently normal allotype male has glandular areas on abdominal sternites III to VIII. The other male, possibly deformed, has only a tiny, off-center, porelike glandular area on sternite III; otherwise the glandular areas on the sternites are as in the allotype. In the latter respect, the paratype male of *eversi* approaches the condition found in *vernus* in which sternite III is said to lack a glandular area.

Dr. Evers and I attempted, without success, to find additional specimens from *Houstonia* flowers at St. Joseph, Missouri, June 25, 1957, and at Valmeyer, Illinois, July 11, 1957.

*Heterothrips gillettei* Moulton

Males and females of this species were taken in company with individuals of *eversi* on *Houstonia nigricans* at Sylvan Grove, Lincoln County, Kansas, June 24, 1957. None was found among the series of *eversi* collected at Manhattan, Kansas.

Previously *gillettei* has been known only from the type locality, Fort Collins, Colorado, where it was found on "rat-tail weed" and yellow sweet clover (Moulton 1929).

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# NORTH AMERICAN TACHINIDAE (DIPTERA)[1]

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The following descriptions of new genera and species are based upon material received from several sources which are cited below. The types are provisionally retained in my collection unless otherwise specified under the descriptions.

*Dolichocodia furacis* new species

Differs from the type species, *D. bivittata* (Coq.), in having the sides of the front and face gray pollinose; abdomen not vittate above; haustellum length not quite equal to head height, etc.

Male.—Front at vertex 0.18 of head width, slightly narrower before triangle, thence strongly divergent downward into facial angle; frontalia red, much narrowed upwards but complete to triangle; frontal bristles extending from antennal base to narrowest part of front; verticals and ocellars weak or hairlike; antenna black, second segment obscurely reddish, one-half as long as third; arista as long as antenna, short plumose to tip; facial carina obsolete below; vibrissae far above oral margin; clypeus moderately depressed at sides; facialia flattened, bare; parafacialia nearly one and one-half times clypeal width, clothed with fine black hairs on upper half or more; cheek over one-half eye height; haustellum moderately slender, sparsely

[1] Contribution No. 2953, from the Department of Entomology, Texas Agricultural Experiment Station.

setose, labella fleshy but not very large; palpus yellow, long and slender to tip.

Thorax black, gray pollinose, notum vittate and rather thickly clothed with erect fine black hairs. Chaetotaxy: acrostichal 1 or 2, 3; dorsocentral 3, 3; intraalar 2; supraalar 3; presutural 1 (outer); posthumeral 2; sternopleural 3; pteropleural 1 (small); scutellum gray pollinose on dark background, with 2 lateral, 1 weak apical and 1 or 2 appressed pairs hairlike discal bristles; postnotal slopes bare; propleuron setose. Legs black, long and quite slender, weakly bristled; mid tibia with one submedian anterodorsal bristle; hind tibia not ciliate. Wing grayish hyaline, tinged with yellow costobasally; veins yellow, third with three small hairs near base and fourth with a broadly rounded stumpless bend; first posterior cell open slightly before extreme wing tip; costal spine vestigial; calypters translucent, pale tawny; epaulet black.

Abdomen black, with heavy opaque gray pollen which shows a yellowish tinge above in some views; hairs long and erect; hypopygium black, rather small, retracted in repose; fifth sternite with a broad V-shaped median excision, lobes black, narrowly exposed. Female unknown.

Length, 7.5 mm.

Holotype: Hidalgo County, Texas, August 19, 1931 (H. J. Reinhard). Paratypes: 2 males same data as type.

*Dolichocodia erratilis* new species

Male only.—Similar to the preceding species except as follows: Front at vertex 0.11 of head width; frontalia completely pinched out before triangle; antenna entirely black, third segment three times length of second; parafacial hardly exceeding clypeal width, with a much denser vestiture of longish black hairs extending to cheek groove; palpus deep brownish to black; cheek largely ventral, two-fifths eye length; abdominal pollen more distinctly yellow above, venter paler or grayish; calypters deep tawny, semitransparent.

Length, 7 mm.

Holotype: "Teotihuacan, Mex., July 15, 1936."

*Admontia ducalis* new species

Differs from all known allied forms in having the small and hind cross veins infuscated.

Male.—Front at vertex 0.37 of head width; parafrontal with seal brown pollen on dark background; frontalia deep velvety brown, twice as wide as parafrontal; broad black-haired parafacial with paler pollen which is sharply delimited at level of lowest frontal bristle when viewed from above; facialia nearly vertical and bristled on lower three-fifths or more; vibrissae on oral margin; two proclinate ocellars; antenna black, third segment fully four times length of second, reaching almost to oral margin and narrower than parafacial; arista black, bare, thickened on basal two-fifths, second segment at least twice longer than wide; proboscis short, palpus black sometimes paler near tip; cheek cinereous, about two-thirds eye length; occiput gray pollinose clothed with pale pile intermixed with coarser black hairs above.

Thorax and scutellum black dusted with grayish pollen, notum marked

with four subshiny black vittae before suture and three behind (intermediate pair coalescent and in most angles appearing as a single broad stripe), all stopping before base of scutellum. Chaetotaxy: acrostichal 2, 3; dorsocentral 2, 3; intraalar 3; supraalar 3; presutural 1 (outer); humeral 3-4; posthumeral 2; sternopleural 2; pteropleural 1 (small); scutellum with 3 lateral, 1 hairlike apical and 1 depressed discal pair behind middle. Legs black, mid tibia with one large median anterodorsal bristle; claws and pulvilli shorter than last tarsal segment. Wing veins margined with brown as noted above, and cubitulus also somewhat infuscated; third vein with two or three hairs near base; first posterior cell open shortly before wing tip, costal spine doubled; epaulet black; calypters opaque, white tinged with yellow.

Abdomen black, with a narrowly interrupted bluish gray pollen band on basal third or more of last three segments; one pair of median marginal bristles on each basal segment, discals on the intermediate and a marginal row on third and fourth segments besides a discal row on the anal; hypopygium black, retracted; forceps black, rather short and terminating in separated, moderately heavy prongs, which in lateral aspect are gently bowed rearward forming a distinctly concave profile on hind side from base to tip; fifth sternite black, retracted.

Female.—Except for sexual differences similar to male.

Length, 6-8.5 mm.

Holotype male and allotype female, N. slope of Popocatepetl, State of Mexico, 1300 ft., August 11, 1954, Univ. of Kansas Mexican Expedition, in the Snow Entomological Museum, Univ. of Kansas. Paratypes: 10 males and 10 females, same data as type.

*Admontia badiceps* new species

Similar to the preceding species from which it differs in the following characters among others.

Male.—Front at vertex 0.4 of head width; parafrontal feebly shining black but with thin brown pollen apparent in some views; frontalia opaque black and well over twice parafrontal width; parafacial with deep brown pollen which is not so sharply delimited above from color of parafrontal; facial ridge bristled to upper third or higher; third antennal segment fully six times longer than second, extending to oral margin and wider than parafacial; arista thickened on proximal three-fifths, second segment slightly bowed and moderately elongated; parafacial beset with black hairs which extend uninterruptedly downward from parafrontal to or a little below level of mid face; cheek black, lightly dusted with gray pollen, about one-half eye length.

Thorax subshining black, notum not distinctly vittate. Chaetotaxy as in *ducalis* except as follows: acrostichal 3, 3; humeral 2-3; presutural 2; sternopleural 3. Wing with a uniform tawny tinge becoming a little paler on hind margin; calypters transparent brown.

Abdomen wholly shining black with silvery pollen on narrow basal margin of segments two to four; slender forceps fused almost to tip, straight in profile with extreme apex bowed forward.

Female.—Front at vertex 0.43 of head width; frontalia slightly reddish

anteriorly and about twice as wide as parafrontal; slender third antennal segment much narrower than parafacial, about four times as long as second segment; parafacial with plumbeous pollen which appears almost silver in direct view from above; fore tarsi flattened and moderately widened.

Length, 4.5-5.5 mm.

Holotype male, Puyallup, Washington, March 23, 1933 (Wm. W. Baker); allotype female, same locality as type, April 25, 1935 (J. Wilcox).

*Muscopteryx petentis* new species

Similar to *M. chaetosula* (type species) but the antennae are entirely black, male front much narrower and almost pinched out before the triangle; other differences are listed below.

Male.—Vertex 0.13 of head width; frontalia deep red, triangular above antennal base becoming obsolete near upper third of front; parafrontal, parafacial and cheek gray pollinose on dark background; lowermost frontal near antennal base, with a row of five to seven infraclinate bristles continuing downward on parafacial about to vibrissal level; latter far above lower edge of head; third antennal segment barely longer than second; arista short, micropubescent, very slender beyond subbulbous base; eye large, oblique, distinctly but not densely haired; proboscis short, labella fleshy; palpus slender, blackish near base becoming paler apically; back of head slightly bulged on lower part, gray pollinose and clothed with black hairs.

Thorax and scutellum black, gray pollinose, notal vittae indistinct behind suture; chaetotaxy as in *chaetosula*; postnotal slope and propleuron setose. Legs black, longish but not very slender; pulvilli and claws subequal to length of last tarsal segment. Wing subhyaline tinged with yellow costobasally; third vein with three to five widely spaced setae extending almost halfway to small cross vein; first posterior cell narrowly open to rarely closed a little before exact wing tip; costal spine strong; calypters light brownish, semitransparent.

Abdomen black, last three segments entirely gray pollinose above when viewed in a flat rear angle but hind margin of each darker and subshiny in most other views; segments two and three usually one pair and four with a row of discals; a marginal row of bristles on last two and a median marginal pair on first two segments; genitalia as in *chaetosula* but the forceps and accessory process distinctly narrower in both rear and profile views.

Female.—Front wider, at vertex 0.3 of head width, gradually widening forward into facial angle; two strong orbitals; outer verticals not differentiated; palpus yellow; calypters white; legs shorter, stouter, claws and pulvilli small.

Length, 5-7 mm.

Holotype male and allotype female: "Cataline Mts., Arizona, April 30, 1941." Paratypes: 1 female, same data as type; 3 males, western slope of Patagonia Mts., Santa Cruz Co., Arizona, August 9, 1955, (F. G. Werner and G. D. Butler), and 1 male, Amortajada Bay, Isla San Jose, Gulf of California, Mexico, March 25, 1953, Sefton Orca Expedition (P. H. Arnaud).

*Celotrophus* new genus

Habitus similar to *Muscopteryx*, but the vibrissal axis nearer to ventral

border of head; epistoma short and full width of clypeus; latter much more deeply depressed; propleura bare.

Head subtriangular in profile, a little wider than high; receding facial profile approximating length of frontal; antennal axis near middle of eye and over three-fourths head height; facialia subperpendicular, with a few bristly hairs next to vibrissae, which are set on level with oral margin; parafacial with a median row of infraclinate bristles extending from near lowermost frontal to cheek groove; frontals rather weak, in a single row, one bristle beneath antennal base; outer verticals hardly differentiated; ocellars weak, divaricate and slightly proclinate; antennae subequal to length of face; bare arista shorter than antenna, thickened on proximal half, middle segment slightly longer than wide; proboscis short, labella large; palpus longer than haustellum; eye hairy, oblique, reaching almost to vibrissal level; cheek in profile barely one-fourth eye length; occiput moderately bulged or convex on lower half. Thoracic chaetotaxy: acrostichal 2, 3; dorsocentral 3, 3; intraalar 3; supraalar 3; postalar 2; presutural 1 (outer); humeral 4-5; pteropleural 1 (small); sternopleural 1, 1; scutellum with 2 lateral, 1 smaller decussate apical pair and 1 hairlike discal pair behind middle; postnotal slope and prosternum bare. Legs stoutish but not very long, moderately bristled, hind tibia not ciliate. Wing reaching well beyond tip of abdomen; first posterior cell narrowly open slightly before extreme wing tip; third vein with three to five setulae near base; costal spine strong. Abdomen narrower than thorax in male but a little wider than abdomen in female; one pair of median marginals on first segment, two pairs on second, a marginal row on third and fourth besides two discal rows on last; intermediate segments each bearing a pair of median discals; sternites covered.

Type species: *Celotrophus soporis* new species.

*Celotrophus soporis* new species

Male.—Front at vertex 0.21 of head width, moderately divergent from near middle to antennal base; head pollen gray to silvery on dark background; uppermost preverticals weak, directed laterally, inner verticals erect; frontalia deep red to black, wider than parafrontal, which bears a few proclinate hairs outside of frontal row; antenna wholly black, third segment large, about twice as wide as parafacial; palpus black, slender to tip.

Thorax and scutellum black, dusted with grayish pollen, notum feebly shiny, with a greenish cast in certain lights, vittae poorly defined behind suture. Legs black, tibiae largely reddish; mid tibia with two anterolateral and fore tibia with two posterolateral bristles; claws and pulvilli a little shorter than terminal segment of tarsus.

Abdomen black, last three segments above with somewhat changeable gray pollen, which extends to hind margin of each but becomes thinner, leaving large sublateral dark maculae on intermediate segments; genitalia as in *Muscopteryx chaetosula,* but the forceps are more slender, barely keeled behind and terminate in a blunt or rounded apex, which bears a microscopic tooth on anterior extremity; accessory process paler or reddish, including broad base, tapering distally from middle to a sharp delicate tip; fifth sternite narrowly and deeply incised, lobes black, sparsely haired.

Female.—Vertex 0.28 of head width; two stoutish proclinate pairs and one weaker suberect pair of orbitals; antenna smaller than in male, third segment barely twice length of second; cheek nearly one-third eye length; legs shorter and stouter, especially the tarsi, which appear serrate on ventral side in profile view; abdomen much more broadly ovate than in male; genitalia caudoventral, retracted, not adapted for piercing.

Length, 5.5-6.5 mm.

Holotype male and allotype female, Amherst, Ohio, May 10, 1924 (H. J. Reinhard). Paratype: 1 male same data as type.

### *Canelomyia* new genus

Small flies with a broad front and long petiolate first posterior cell as in *Tortriciophaga,* but the eyes are distinctly haired, facialia bare and parafacialia with a median row of bristles. Besides the three last mentioned items, the present genus also agrees in other essential characters with *Celotrophus,* except as follows:

Head nearly one-third wider than high, facial profile strongly receding and a trifle longer than frontal; vibrissal axis hardly two-fifths length of antennal; clypeus moderately depressed, facialia flattened, equal to width of parafacial inverted; male antenna reaching to oral margin, third segment four and one-half to five times longer than second; arista micropubescent; eye rather small, not nearly reaching vibrissal level; cheek in profile about one-third eye length; back of head flattened or gently convex on entire surface. Thoracic chaetotaxy as in *Celotrophus,* except as follows: dorsocentral 2, 3; acrostichal 3, 3; sternopleural 3; scutellum with 3 lateral pairs and 1 small or hairlike apical pair. Wing normal in size and shape; petiole of first posterior cell three-fifths length of apical cross vein, reaching costa shortly before wing tip; third vein with one small setule near base. Abdomen long ovate in male; one pair of median marginal bristles on each basal segment, one pair of median discals on segments two and three besides a row on latter set well in front of hind margin; anal segment with two or more irregular rows behind middle above.

Type species: *Canelomyia fumator* new species.

### *Canelomyia fumator* new species

Male only.—Head cinereous pollinose on dark ground color; front wide, at vertex 0.37 of head width; frontalia deep red to blackish, equal to parafrontal width; proclinate ocellars distinct; two pairs of proclinate orbitals and two pairs of verticals; frontals in a single row, two bristles below antennal base; antenna wholly black, third segment wider than parafacial below; arista black, moderately thickened to near middle, second segment slightly longer than thick; palpus subequal to length of labella with tip slightly widened, blackish basally and paler or brownish beyond middle; occiput sparsely black-haired.

Thorax and scutellum black, with rather thin gray pollen, which appears densest in a flat rear view, especially before suture; notum marked with four well defined vittae before suture; postnotal slope and prosternum setose. Legs black, not very strongly bristled; mid tibia with one median antero-

lateral bristle. Wing subhyaline with a slight uniform tawny tinge; cubitulus broadly rounded, without stump or fold; hind cross vein nearly midway between latter and small cross vein; calypters translucent white.

Abdomen shining black, with sharply defined silvery pollen bands on basal fourth to third of last three segments; hypopygium small, black, retracted; fifth sternite with a V-shaped apical excision, lobes narrowly exposed, black.

Length, 5.5 mm.

Holotype: Canelo, Arizona, October 11, 1955 (G. D. Butler). Paratype: 1 male same data as type.

*Metopomuscopteryx incurata* new species

With the habitus of the type species (*M. tibialis* Coq.) but the tibiae are not sharply contrasting in color with the femora or tarsi, and there are decisive differences in the genitalia.

Male.—Head gray pollinose on dark ground color; front very prominent at antennal base, narrowed upward to 0.2 of head width at vertex; frontalia black, wider than parafrontal; ocellars and inner verticals long but not very stout; frontal row extending from triangle to antennal base; antenna black, first segment long and subequal to second, which bears a heavy vestiture of coarse black hairs on front margin, third segment about one and one-half times length of second; arista black, bare, thickened on basal fourth; face receding below, its sides thickly clothed with long black hairs; facial ridge with few bristly hairs on lower extremity; vibrissae doubled, set far above lower margin of head; cheek in profile one-fourth eye length, clothed with long black hairs; eye rather densely pilose; proboscis short, palpus yellow, rather short and slender; back of head strongly convex, gray pollinose and clothed with black hairs.

Thorax and scutellum black, dusted with gray pollen, dorsal vittae indistinct; acrostichal 2, 3 (none immediately in front of suture); dorsocentral 3, 3; intraalar 3; supraalar 3; presutural 1 (outer); humeral 5; sternopleural normally 3; pteropleural 1 (small); scutellum with 2 lateral, 1 large decussate apical pair and 1 long erect discal pair; postnotal slope and propleuron bare. Wing gray hyaline with narrow base, costal margin and cross veins slightly infuscated; third vein with two or three long setulae near base; first posterior cell narrowly open shortly before the wing tip; costal spine small; calypters white; epaulet black. Legs moderately long and slender; mid tibia with three stoutish bristles on outer front side and villous hairs on inner margin; claws and pulvilli subequal in length to last tarsal segment.

Abdomen black with opaque gray pollen on entire upper surface of last three segments and hind margin of first; latter with one pair of median marginals, second segment with two pairs and third with a complete marginal row; anal segment with long erect bristles over most of upper surface and two or more discal pairs on intermediate segments; hypopygium black, rather small and retracted; fused forceps very slender and approximating length of hind basitarsus; accessory process expanded inwardly into a broad platelike base, thence narrowed and fingerlike to apex, in profile distinctly wider and a little shorter than forceps; sternites narrowly exposed.

Female.—Similar to male, except for the usual sexual differences.

Length, 8.5-9 mm.

Holotype male and allotype female, Oak Creek Canyon, Arizona, March 31, 1956 (F. Werner and G. Butler).

*Metopomuscopteryx fatigantis* new species

Male only.—Differs most obviously from *tibialis* and *incurata* in having the anterolateral and posterolateral bristles of the middle and hind tibiae strikingly elongated, some bristles on the former exceeding the full tibial length.

Front at vertex 0.17 of head width; proximal segments of antenna obscurely reddish; cheek nearly one-half eye length; tibiae and trochanters pale or reddish yellow in ground color; claws and pulvilli longer than apical tarsal segment; otherwise as in the preceding species.

Length, 8.5 mm.

Holotype: Temescal Canyon, Los Angeles Co., California, February 7, 1954 (W. McDonald). Paratype: 1 male, Ft. Baker Res., Humboldt Co., California, April 15, 1955 (D. L. Dahlsten).

*Oraphasmophaga* new genus

Type species: *Paraphasmophaga pictipennis* Reinhard, 1935, Ann. Ent. Soc. Amer., 28: 167-168.

Differs from *Paraphasmophaga* mainly as follows: Head barely as wide as high, facial profile almost as long as frontal; eye descending slightly below level of mid face; cheek subequal to eye length; parafacial one-fourth wider than elongate deeply sunk clypeus; facialia subvertical, short-bristled to upper fourth; proboscis and labella unusually small; bare small palpus hardly exceeding width of haustellum; hind cross vein retracted, joining fourth about one-third the distance from small cross vein to cubitulus; last section of fifth vein three-fourths length of preceding section.

Additional details are listed in the reference cited above.

# AN INEXPENSIVE UNIT FOR CONVERTING A VACUUM CLEANER TO AN INSECT ASPIRATOR[1]

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The need for an aspirator in handling test insects often arises during the course of an entomological investigation. Many times there is a need for an additional aspirator for short periods to supplement those all ready in use. It was for this purpose that a simple apparatus was designed for putting a conventional vacuum cleaner into service as an insect aspirator.

The apparatus assembled and ready for use is illustrated in Figure 1. The vacuum cleaner furnishes a source of suction through a small sheet

[1] Contribution from Missouri Agricultural Experiment Station, Journal Series No. 1768. Approved by Director.

metal manifold. This manifold was constructed by a local tinsmith and consists of a cylindrical tube measuring thirteen inches in length by two inches in diameter. Three small holes, spaced an inch apart, were drilled into this tube. Into these holes were soldered three valve stems of the type commonly used in bicycle inner tubes, which are available at almost any automotive parts store. These valve stems had the valves removed and were fittted with regular valve caps. One end of the manifold was constructed to fit snugly into the inlet provided for the vacuum cleaner hose. It was

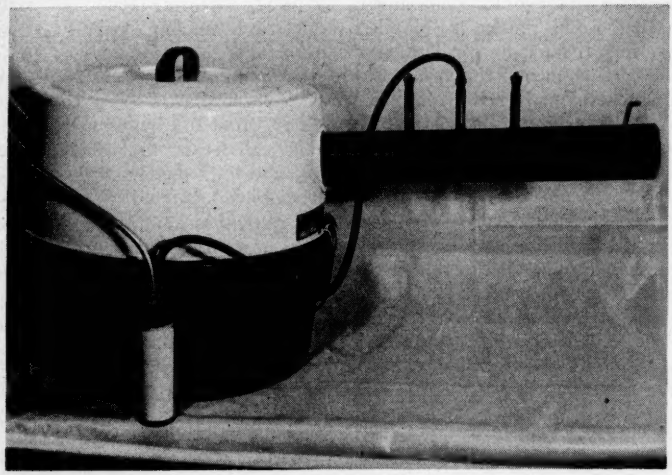

FIG. 1.—The assembled aspirator unit ready for use.

found that the addition of a small layer of solder around this end of the cylinder was all that was necessary for providing a snug fit and that a special gasket was not necessary for good operation of the aspirator. In the other end of the manifold was fitted a damper, or butterfly, type valve. This valve is used for regulating the air flow coming through the cylinder. Through experience, the proper air flow for handling different insects without injury can easily be determined.

To ready the vacuum cleaner for use as an aspirator all that need be done is to insert the manifold, remove the valve caps, and connect the collection tubes to the valve stems. A conventional type collection tube is used and is connected to the manifold by rubber tubing, which is forced onto the valve stems. The proper air flow can be obtained in a few minutes by trial and error adjustment of the butterfly valve. One, two, or three collection tubes can be used at one time. The vacuum cleaner furnishes ample suction for a greater number of tubes if desired.

The total cost of the complete apparatus, including the new price of the vacuum cleaner, is approximately $35. The manifold tube can be made for approximately $5.

# A BUMBLEBEE THIEVING FROM A HONEYBEE HIVE

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It has occasionally been reported (Toumanoff, 1939; Borchert, 1949) that honeybee colonies suffer robbery by bumblebees, their nearest relatives, sometimes with considerably destructive results (Kempf, 1952). However, compared with the attacks by other social insects, notably by some hornets and ants, the activities of bumblebees seem far less notorious.

On September 16, 1957, a worker of *Bombus speciosus* Smith, the commonest bumblebee in the vicinity of Sapporo, Japan, appeared in our apiary, perhaps attracted to the odor of honey from an exposed hive, which was being inspected at that time. After several circular flights around the hive, she landed on the stored honey area and immediately began to suck honey from the comb. Most of the honeybee workers paid little attention to her, but some noticed this unwelcome guest and approached her with extended antennae, a well known warning posture of the honeybee. The bumblebee responded to this inspection with a posture characteristic of its genus: the body was gradually lowered at the side away from the approaching honeybee, and the middle and hind legs of the near side were raised. Contact between the two species of bees always resulted in a confused battle. In no case did the bumblebee exhibit an aggressive attitude; instead it tried to fly away with little resistance. After several such combats and intervening periods of robbery, the bumblebee flew away without suffering any injuries.

In Sapporo, bee hives are visited in the autumn by workers of *B. speciosus* and, more often, by a small wasp, *Vespula lewisii* Cameron. But in most cases, the honeybee workers do not allow these intruders to enter the hive. Although the slender wasps are more agile and combative, they usually retreat from the attack of nest guards and do not attempt further entry. They can reach the storage combs only when the bee colony is too weak to defend them effectively at the entrance to the hive, or as shown above, when the hive is exposed for apicultural management.

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